INNOVATION DIFFUSION AMONG FARMERS IN DEVELOPING COUNTRIES

A Dissertation

by

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ABSTRACT

Agriculture plays a fundamental role in the global economy. To accomplish the economical and feasible improvement in agricultural production, a more complete understanding of how innovations move through different channels is necessary. Farmers in developing countries have many disadvantages, including barriers to innovation exchange. Better understanding the diffusion process in developing countries is necessary to improve adoption. The framework utilized by this study is Rogers' Diffusion Theory. The diffusion process in developing communities is equivalent to that of classical theory but with more emphasis placed on the knowledge, persuasion, and decision components as needs by the adopters. The purpose of this study was to describe the adopter characteristics of agriculturists, the innovation traits that facilitate adoption, and the adoption process itself, and identify the elements and barriers of information transmission in Brazil.

A questionnaire consisting of eight attitudinal constructs and one demographic construct was administered to 344 participants in this study. Each of the constructs had a Cronbach's Alpha greater than 0.7. Data were analyzed using descriptive and correlational statistics, including stepwise regression. Respondent demographics showed that 22% of the sample was female and the average age for the respondents was 41 years. Adopter characteristics were identified as educated, more conscious of social status, more able to grasp and use a technology, and likely to be opinion leaders. Innovation characteristics conducive to adoption were innovations that were simple,

easily communicable, socially accepted, and had high levels of utility to the individual. The adoption process was found to be consistent with Rogers' characterization of agricultural producers. The elements of transmission that contributed to adoption were high levels of observability, compatibility and low complexity. The identified barriers to transmission were high complexity and low compatibility innovations.

Recommendations for practitioners to facilitate adoption were to target opinion leaders, minimize complexity, and increase education. Recommendations for future research included replication of the study in the same population and also in neighboring populations. Future research should explore the impacts of societal factors, increased education, and the ability to quantify innovation traits.

DEDICATION

This dissertation is dedicated to my wife and family who are the most important people in my life. My wife, Mary Davis Wynn, has been a constant source of motivation and encouragement. Without her I would not have reached completion. She is the love of my life and I am eternally blessed for her patience and support as I complete this process.

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TABLE OF CONTENTS

Page

LIST OF TABLES

Page

CHAPTER I

INTRODUCTION

Agriculture plays a fundamental role in the global economy. Population projections indicate that current food supplies are increasingly less adequate to meet demand (Godfray, et al., 2010). As food supply and security become more prominent societal issues, there is a need to better understand how food supply and security can be improved in an economical and feasible manner. Science and technology have been shown to provide a feasible solution to increase food security (Beddington, 2010). Technologies that have been suggested to improve food security are agrotechnologies, and a more transparent exchange of information can facilitate the adoption of agrotechnologies (Carvalho, 2006). To accomplish the economical and feasible improvement in agricultural production, a more complete understanding of how agricultural technology and information move through different channels is necessary. Further investigation into the primary drivers of information dissemination as well as the discernment of methods effective in capitalizing on the primary drivers are also crucial for addressing food supply and security problems.

Problem Statement

Globally, agriculture has been shown to be an increasingly smaller component of the world's economy (Swanson, 2006). However, agriculture worldwide has continued to grow as the world strives to feed a growing population. Developing countries are particularly dependent on agriculture. As an economic component, agriculture is more

relied on by developing nations as an economical driver than it is by developed nations, specifically with regard to food security (Fritschel, 2003). The changing environment of global agriculture requires constant improvements in agricultural practices. Population increases, climate change, and policy initiatives all impact developing countries' need for improved agricultural practices (Pretty, et al., 2010). Agricultural production practices can be improved through technology. Nin, Arndt, and Preckel (2003) found that as agricultural technology adoption increased in developing countries, the agricultural production increased at a greater rate. As agricultural production increases, wealth in developing countries improves as well. Research by Thirtle, Lin, and Piesse (2003) found that agricultural improvements in developing countries and the resulting increases in GDP had a disproportionately positive effect on wealth distribution. To preserve the integrity of the global economy, protect sustainability of developing economies, and ensure an adequate and secure supply of food worldwide, it is important to more completely understand the role of information in agriculture.

Food Security and Information Exchange

Food security and agricultural productivity in developing countries have a strong potential for growth but need a conduit through which information and technology can be disseminated. Agricultural industries in developing countries present a unique potential to serve as an engine for economic growth (Byerlee, de Janvry, & Sadoulet, 2009). Rapid transfer of information can help fuel the economic potential of agricultural industries. More effective information distribution can be achieved in developing countries through clear, concise, and transparent communication (Strong, 2013).

Information asymmetry has been identified as an element in the disparity between increased technological advances and minimal productivity growth (Aker, 2011). Greater levels of poverty and wealth disparity exist in areas with wide information asymmetries. Wealth redistribution and production efficiencies have been identified in the literature as resulting from reduced informational asymmetries (Svensson & Yanagizawa, 2009). Both production efficiencies and wealth distribution are directly impacted by the communication of market pricing (Sulaiman, Hall, Kalaivani, Dorai, & Reddy, 2012). Market price information is, therefore, an effective vehicle to achieve greater efficiency and economic benefit. Technology transfer within developing economies has also been shown to be effective in achieving improved production and wealth distribution efficiency.

Information exchange is one way to achieve greater production and farmer welfare improvements. Technology has been defined as a form of information and has been shown to be effective in improving productivity and wealth (Mendola, 2007). Improvements in agricultural yields are a primary factor in improving agricultural productivity. Transfers of agricultural yield technology have direct implications for productivity improvement in developing countries (Minten & Barrett, 2008). The most promising venue for agricultural technology development is through university research. University research has created many new technologies for farmers, but there is usually a disparity between the amount and rate of adoption by farmers (Abdulai & Huffman, 2005). The greater rates of non-adoption are more prevalent in developing countries than in developed countries. Lee (2005) found that information disparities in developing

countries are a large contributor to technology non-adoption. Overcoming information barriers pertaining to technology transfer represents a key hurdle in improving the wellbeing of farmers in developing countries

Price information is a key component of information that impacts the productivity and economic welfare of farmers. Price discovery mechanisms differ widely between developed and developing economies. Developed economies often utilize a form of free market to achieve effective price discovery in the form of futures markets (Figuerola-Ferretti & Gonzalo, 2010). Futures markets represent a means of information communication with minimal information asymmetry. The efficiencies presented by a futures market price discovery process improve both the distribution of economic wealth and the efficiency of production. Efficient pricing achieved by the futures marketing process is a result of improved communication, low barriers to communication, and the accessibility of information (Oliven & Rietz, 2004). Price risk associated with information asymmetries is a barrier in the communication process that influences the decision to adopt an innovation. Economic profits can be expressed in terms of time, energy, or money (Green, Mas-Colell, & Whinston, 1995). Positive perceived economic profits have been shown to be significant factors that enhance the adoption process (Koundouri, Nauges, & Tzouvelekas, 2006). Ensuring positive perceived economic profits through increased information symmetry is a necessary part of implementing effective technology transfer and improving economic benefits and productivity for farmers.

Information Asymmetries in Developing Countries

Developing countries have been shown to exhibit wide information asymmetries with regard to price. Developing countries are often characterized by significant barriers to communication. Barriers to communication result from limited educational availability, low degrees of technology adoption, and local market collusion (Moriba, Kandeh, & Edwards, 2011). Communication barriers have a substantial impact on technology communication. High communication costs within a system have been shown to exhibit lower levels of productivity and a wider disparity of wealth (Bardhan & Mookherjee, 2005). Improved communication of technology can reduce waste and improve production efficiency. Effective governance, accountability and regulatory quality are two elements that have been identified as areas that can significantly impact information communication technology in developing countries (Meso, Datta, & Mbarika, 2006). Increasing government reliability and regulatory quality through accountability can reduce communication costs and improve the adoption of new technologies. Increasing accountability within a communication system can also improve the flow of market information in developing countries.

In the field of international development, the Association of International Agricultural and Extension Education (AIAEE) has published extensive research regarding technology transfer from around the world. One vehicle used by members of AIAEE to evaluate technology transfer is the integrated pest management (IPM) programs in developing countries. Research conducted in farmer field schools in Kenya identified the perceptions of rural farmers to IPM technology (Bunyatta, Mureithi,

Onyango, & Ngesa, 2006). Farmer field schools as a mode of communication was further developed by Erbaugh, Donnermeyer, Amujal, and Kidoido (2010) via their research concerning farmer knowledge in Uganda. Technology transfer as a policy initiative was recommended by Tripp, Wijeratne, and Piyadada (2005) as a mode of ensuring that information dissemination and sustainable production practices were adopted by a broader audience of farmers. Vocational education and training have been identified as a vehicle to communicate technology transfer to farmers (Erbaugh, Kibwika, & Donnermeyer, 2007). Effective training and educational practices should be routinely evaluated to maintain a better understanding of farmers' education and training needs.

Information exchange among farmers in developed countries is typically consistent and transparent. Developed economies utilize both formal and informal institutions to transfer information and technologies. Institutions utilized by developed countries to transfer information and technology are normally trusted by participants for accuracy and fairness in exchanging information (Gerxhani, 2004). Trusted information exchange is important for innovations to permeate societies. Farmers in the United States rely on large scale technological innovations as the foundation of commercial farm management (McBratney, Whelan, Ancev, & Bouma, 2005). Technologies such as precision agriculture and effective futures markets have minimized information asymmetries. Ates and Wang (2005) found that futures markets in the US are effective at determining commodity market price through information transparency. Transparency of information in developed markets has led to a more efficient and

productive agricultural sector in developed countries. Farmers controlling for price and production risks through trusted and transparent information exchange has been shown to lead to more efficient agricultural production (MacDonald, et al., 2004). Food security in developed countries is thus less critical than in developing countries.

Developing countries experience information exchange in different ways than their developed counterparts. Developing countries often exhibit distinct information gaps at the farm level. Information gaps are most pronounced in countries where new technologies resulting from intellectual property rights are poorly enforced (Hoekman, Maskus, & Saggi, 2005). Farmers are either not aware of new information and technologies or are not able to effectively implement new information and technologies feasibly. Knowledge of informational and technological innovation has been shown to be hindered by low levels of awareness in developing countries (van der Gaast, Begg, & Flamos, 2009). Low awareness has been specifically linked to low levels of education. Education deficiencies have been identified as a primary cause of non-adoption of technologies and as barriers to information flow. Farmer awareness limitations have been found to be more strongly linked to educational deficiencies than to gender or other demographic components (Dutta, 2009). Improving innovation exchange is crucial at the farm level to accelerate economic development and enhance food security.

Educational Needs

Education is a key element in improving information exchange in developing countries. Educational improvements have been shown to influence organizational behavior specifically regarding the acceptance of new technologies (Baker, Al-Gahtani,

& Hubona, 2007). Organizational behavior influencing technology adoption can be influenced by outreach programs designed to communicate the technology or information to the needs of the communities. One avenue to improve farmer education with respect to technology and information is through farmer field schools. Farmer field schools have been found to be effective in improving farmers' education and perception of new technologies in a context that is consistent with their societal norms (van den Berg & Jiggins, 2007). Information transparency can also be achieved through education. Educating farmers on new technologies by utilizing existing and accepted communications media has been shown to provide more effective and impactful results regarding the transfer of information. This blending of information sources has been shown to ease the transition into newer technologies and improve farmers' knowledge simultaneously (James, 2005). With the internet emerging as a functional tool, farmers in developing countries need to have the knowledge to access electronic resources including price, technology, and developmental information. Poor computing resources and low technological cognitive ability have been identified as barriers to farmers' use of internet communication technology as a mode of information transfer (Kshetri, 2007). Understanding and improving farmers' educational needs is a key element in improving information dissemination in developing countries.

Information Diffusion in Developing Markets

Diffusion literature is broad regarding developing markets and an expansive proportion is devoted to understanding the market development process. Market development in diffusion literature varies widely regarding specific methods that can be

applied to improve information diffusion within developing countries. One method regarded as necessary to effect market development is the transformation of the agricultural industry structure to incorporate more efficient and effective means to transfer information and technology. Restructuring of the agricultural sector has been identified as a necessary step in the market development process in developing countries (Rearden, Barrett, Berdegue, & Swinnen, 2009). Effectively impacting the diffusion of technologies and information requires a more thorough understanding of how innovations can effectively be dispersed through different societal groups. Spielman (2005) identified the need for better understanding of how innovations are disseminated in developing countries as a primary research initiative. Within the context of information diffusion in developing countries, a more thorough understanding of how social and economic factors interrelate is necessary to improve the diffusion process. Diffusion in developing markets is highly dependent on social elements. Individuals are more likely to adopt an innovation when it is highly acceptable within the individual's social context, is desirable, and is presented through a verified medium of exchange (Young, 2009). Informational exchange mediums are integral parts of the information exchange process and should be understood to ensure effectively overcome barriers to communication.

Farmers in developing countries have many disadvantages to farmers in countries with developed economies. Disadvantages to farmers include barriers to information and technological exchange (Godfray, et al., 2010). Lack of education and communication barriers have been identified as primary hindrances to the dissemination

of information and technology to farmers in developing countries (Dutta, 2009). The literature has a gap concerning how education and communication techniques can best be disseminated to farmers in developing countries is broad and inconclusive. It has been argued that farmer field school and other means of non-formal education are an appropriate venue to communicate technologies (Binam, Sylla, Diarra, & Nyambi, 2003). The establishment of futures exchanges in developing countries has been suggested as a means to effectively disseminate transparent price information (Sampson, 2012). Many theories exist about the best way to disseminate information and technology to farmers in developing countries although none have been demonstrated to be ideal for all settings (Wellard, Rafanomezana, Nyirenda, Okotel, & Subbey, 2012). Societal influences have been shown to be instrumental in determining the most effective method to communicate information and technological innovations to farmers in developing countries (Huang, Shih, & Wu, 2011). Social influence at the farm level is highly contextual. A firmer grasp of the fundamental elements impacting societal influence in developing countries and thus the context of best dissemination practices is important for researchers to understand in order to appropriately affect positive change (Quaim, 2005).

This study sought to address recommendations from the National Research Agenda of the American Association of Agricultural Education (Roberts, Harder, & Brashears, 2016) and existing literature to improve the practical comprehension of information diffusion within production agriculture. This line of inquiry specifically addresses Research priority 2, “New Technologies, Practices, and Product Adoption

Decision." As new technologies emerge it is important to have a grasp on the key elements impacting the adoption and diffusion of information and technology. Research priority 6, "Vibrant, Resilient Communities" was also identified as a tenet of this study. Understanding the impacts of technology use in production agriculture is fundamental actuating positive community change as an output of new technology adoption. More thoroughly understanding the diffusion of information and innovation process as it relates to developing countries is necessary to improve the ability of practitioners to impact change and accelerate developing market growth.

CHAPTER II

THEORETICAL FRAMEWORK

The underlying framework utilized by this study to evaluate the diffusion of information and technology in developing countries is Rogers' (2003) Diffusion of Innovations theory. Innovation diffusion has frequently been utilized in current literature to analyze technological and information exchange in a multitude of settings. Rogers (2003) proposed in his seminal work that diffusion theory was applicable to many disciplines including agriculture and business. The diffusion framework has been used to evaluate both technology and information in various fields. Interdisciplinary work has been conducted to determine the validity of diffusion theory in different contexts. MacVaugh and Schiavone (2010) found that a more robust understanding of innovation diffusion can be achieved when innovation diffusion is evaluated at different levels of social systems and contextual domains. Information exchange can be characterized by diffusion theory at different levels. Research conducted within the domain of information transfer has found that information diffusion can be effectively analyzed using diffusion theory at the local, national, and international levels (Verdolini & Galeotti, 2011). Technology as an innovation has been effectively evaluated using the diffusion framework in different settings as well. Hilbert (2010) utilized diffusion of innovation theory to evaluate the impacts of technological advances on Latin American populations and the probable impacts resulting from future increases. Innovation diffusion is a powerful framework that can be used to analyze both technological and

informational innovations at micro and macro political levels and within various individual and social contexts as well.

Innovations and Adoption Decisions

Rogers (2003) defined an innovation as an idea, object, or behavior that is perceived as new by the target audience. The diffusion of innovation framework revolves around the interaction between innovation qualities, peer networks, and individual needs to describe how innovations are adopted or rejected. Contemporary research in innovation diffusion found that interaction between the innovation, peer networks and individual needs is highly contextual (Atun, de Jongh, Secci, Ohiri, & Adeyi, 2010). Rogers identified four key elements in the diffusion process including the innovation itself, the channels through which the innovation is communicated, time, and the social system in which the innovation is enacted. MacVaugh and Schiavone (2010) noted that the four elements in diffusion are multidimensional and should be evaluated at the micro, meso, and macro levels of a society and context to achieve a more robust understanding of the diffusion and decision process. The final decision process was defined by Rogers (2003) to be governed by who makes the decision within a context and also whether the decision was made freely. Research has demonstrated that individual analysis of the adopter's final decision is generalizable to the aggregate level when bounded within the same context (Zhang & Nutall, 2011). The final adoption decision was posited by Rogers to fall into three distinct categories. The categories of adopter decisions include optional innovation-decision, the collective innovation-decision, and the authority innovation-decision. Under the optional innovation-decision,

the adoption decision is made by an individual within the social system who is distinguished from the other members of the system. The collective innovation-decision is characterized as being made by all individuals within a system, and the authority innovation-decision is defined as being made by a few individuals within the social system. Adoption decisions are not mutually exclusive. Under certain cases, the adoption of more complex innovations can often require two or more types of adoption decisions. Adoption decisions made under authoritative innovation-decision are often found to meet stronger resistance to adoption at the implementation stage (Borrego, Froy, & Hall, 2010). In the context of production agriculture, the adoption decision process has often been modeled based on economic rationale and efficiency gains from innovation adoption. Recent empirical studies have demonstrated that inefficient and economically poor innovations are often adopted in agricultural communities as a result of overpowering community forces and externalities influencing the adoption decision (Sneddon, Soutar, & Mazzarol, 2011).

The innovation decision process within the diffusion framework is posited to have five stages (Rogers, 2003). The five stages of the decision process include knowledge, persuasion, decision, implementation, and confirmation. The knowledge component of the decision process consists of an individual being made aware of the existence and function of an innovation. Knowledge about an innovation allows the adopter to understand the potential implications of the innovation to the adopter. The persuasion stage of the decision process is when the individual, having knowledge of the innovation, develops an attitude toward the innovation. Adopter attitude is a critical

component of the decision process at the early stages. One of the primary challenges by contemporary theory to the seminal persuasion component is the inability of the classical theory to account for demographic differences among adopters (Abukhzam & Lee, 2010). The decision element of the decision process involves the individual making a decision or attitude adjustment that results in either innovation adoption or rejection. Mass media has been found to play a fundamental role in adoption particularly at the knowledge, persuasion, and decision stages of the process (Green, Ottoson, Garcia, & Robert, 2009). The implementation stage is typified by the individual overtly using the innovation. Implementation is the first tangible stage of the innovation adoption process. The confirmation stage is characterized by the individual evaluating the innovation-decision that has been made and choosing to continue or reverse the decision based on information collected from the use of the innovation. Rogers (2003) presented the stages in the decision process as being sequential in occurrence. Recent empirical evidence suggests that the factors influencing the adoption process may be dynamic in many cases (Mendoza, Carroll, & Stern, 2010). Agricultural producers present an additional variable in evaluating the innovation decision process. Agricultural innovations are often subject to greater constraints than the traditional innovation in that agricultural innovations are often climate specific. Similarly agricultural producers in different geographic and socioeconomic regions are often subject to mutually exclusive constraints including financial limitations and climactic differences. Research evaluating the ability for agricultural producers in both developed and developing countries has found that the most binding constraints in innovation diffusion relate to

financial barriers, occur at the adoption level, and are more pronounced in agricultural producers in developing countries (Lybbert & Sumner, 2012).

Rate of Adoption

In addition to defining a process of adoption, Rogers (2003) also posited factors influencing the adoption rate. The rate of adoption is the relative speed with which individuals in a system adopt an innovation. Under the classical model of innovation adoption, rates of adoption were generally considered to be linear in nature. With the advent of the internet, social media, and faster mass communication the rates of diffusion have changed in both speed and complexity (Peres, Muller, & Mahajan, 2010). Key factors identified by Rogers (2003) that influence the type of innovation-decision, the type of communication channels through which the innovation was diffused, the type of social system in which the innovation was diffused, and the efforts of change agents seeking to facilitate diffusion. Rogers (2003) noted that the type of innovation-decision had a significant impact on the diffusion process. Specifically, Rogers' noted that individual innovation-decisions and optional innovation-decisions were generally adopted more quickly than organizational innovation-decisions. The type of communication system in which the diffusion process is actuated also plays a role. Rogers (2003) noted that communication systems dependent on interpersonal communication tended to result in a slower diffusion adoption rate than mass media communication. The social system under which the innovation is diffused is important to innovation diffusion also. A more open system in which the communication system is more closely linked to the social system generally results in a more rapid innovation

diffusion process. Broader communication is not always the best scenario to affect innovation adoption. Under circumstances where social influence is the more powerful driver even in the midst of rapid communication it has been found that the innovation adoption process can be disrupted (Delre, Jager, Bijmolt, & Janssen, 2010). Change agent interaction was the final component identified by Rogers (2003) as the impacting the rate of diffusion. Change agents are classified by Rogers (2003) as individuals outside a system seeking to affect diffusion. Change agents located within the social system or networks are referred to as opinion leaders. Cho, Hwang, and Lee (2012) expanded the definition of opinion leaders to encompass degrees of communication behavior utilized by the opinion leaders within a system. When the impact of change agents reaches a maximum level then the innovation achieves critical mass. Critical mass within the diffusion framework pertains to the level of adoption of an innovation after which the adoption will continue to spread without the additional efforts of change agents. There have been some discrepancies in contemporary research regarding the importance of individual change agents in achieving critical mass. Empirical evidence has suggested that the probability of change agents triggering a critical mass in adoption is only marginally higher than the probability of non-change agents (van Eck, Jager, & Leeflang, 2011). In the contexts where change agents are appropriate drivers of innovation diffusion those change agents with high levels of social ability have been found to influence more rapid adoption whereas change agents with a broader range of social contacts are more effective at influencing greater numbers of adopters (Cho, Hwang, & Lee, 2012). Change agents in agriculture play a significant role in developing

countries. Lower income agricultural producers typically associated with developing countries have been found to rely more heavily on peer networks than on extension personnel for innovation information. The most effective change agents within the small agricultural communities of developing countries are opinion leaders (Amlaku, Solkner, Puskur, & Wurzinger, 2012).

Innovation Characteristics

Characteristics of the innovation itself play a role in the adoption process. Rogers (2003) identified five primary attributes of an innovation that impact its adoption. The five innovation attributes are the relative advantage of the innovation, the compatibility of the innovation, the complexity of the innovation, an innovation's trialability, and the ability of the adopter to observe the effects of the innovation. Relative advantage is generally considered to be the degree to which an innovation is superior to the innovation it replaces (Rogers, 2003). Relative advantage can be expressed in economic or social terms. Compatibility is the degree to which the innovation is compatible with the needs, values, and experiences of the adopters. Innovations consistent with the existing norms of the adopter tend to achieve greater rates of adoption. Complexity of an innovation is related to the ease with which the innovation can be understood and used. Greater degrees of complexity tend to result in lower levels of innovation adoption. Trialability is the innovation attribute associated with the adopter's ability to test the innovation. Trialabilty is a function of access, price, and divisibility. Higher levels of trialability tend to result in greater levels of adoption. The fifth characteristic identified by Rogers (2003) was observability. Observability

revolves around how well others can see the characteristics and traits of the innovation. Higher levels of observability are generally associated with greater levels of innovation adoption. In many agriculturally specific applications of innovation diffusion the concepts of relative advantage, compatibility, and complexity tend to be more apparent to adopters than trialability and observability (Moore, Murphrey, Degenhart, Vestal, & Loux, 2012). Increasing the transparency and apparent characteristics of an innovation can help to improve the ability and speed of an innovation to diffuse in an agricultural context. When working with agricultural producers it has been found that the characteristics of an innovation can be more clearly portrayed by maintaining the economic implications of the innovation as it relates to the producer in the forefront of the diffusion conversation (Ozcatalbas & Brumfield, 2010). Presenting the innovation to agricultural producers using concrete methods and pertinent examples can also facilitate the adoption process.

Adopter Categories

In addition to innovation characteristics, adopter categories were also defined as a component of the adoption process. Adopter categories classify potential adopters based on the adopters' individual idealistic characteristics. Rogers (2003) proposed five adopter categories that he posited would maintain the shape of an 'S' curve. The five categories proposed by Rogers were innovators, early adopters, early majority, late majority, and laggards. Innovators were categorized as being generally venturesome. Adopters in the innovator category were posited to control significant financial resources, have a high degree of mental acuity, and also maintain high risk tolerances.

Early adopters were associated with high levels of social standing within the community. Early adopters were also considered to maintain above average levels of intelligence and risk tolerance. The adopters in the early adopter category were generally posited to be older and more established than adopters in the innovator category of adoption. The early majority category was found to have many of the same characteristics as the early adopters with the primary distinction being that early majority adopters tended to not be in positions of leadership. Early majority adopters also were characterized by a lower risk tolerance than adopters in the innovator and early adopter categories. The late majority adopter category was noted to have higher levels of skepticism about an innovation and tended to adopt only after adoption of the innovation became an economic or social necessity. The adopters in the late majority adopter category tended to have fewer resources and maintained a higher degree of risk aversion. The fifth adopter category defined by Rogers was the laggard category. Laggards were determined to be the final adopters of an innovation within a social system. Laggards tended to be isolated from other adopters and maintained traditional practices to more modern techniques. Financial resources were found to be comparatively scare for adopters in the laggard category and thus the adopters in the laggard category maintained a very high level of risk aversion. In some agricultural settings, adopter categories have been found to deviate from the classical theory. Based on societal context and values some of the adoption stages have been found to be omitted from the process (Moore, Murphrey, Degenhart, Vestal, & Loux, 2012). The categorization of agricultural producers into specific adopter categories can also be difficult. Agricultural producers

tend to have a greater degree of risk aversion than conventional innovation adopters. Similarly the costs associated with many agricultural innovations are often high and irreversible. Consequently a larger portion of the population of agricultural producers will choose to adopt later in the process (Howley, Donoghue, & Heanue, 2012).

Rogers (2003) identified the characteristics and processes of innovation adoption and diffusion within broad theoretical contexts. Innovation diffusion applies to agricultural producers in developing countries much the same as in other settings but with some unique nuances. Communication channels and social system represent a greater element of the innovation process when dealing with agricultural producers. As agricultural producers in developing countries are typically community oriented, effective innovation diffusion requires a strong acceptance by the producer's peers. The adoption decision in agricultural communities is thus influenced not only by the individual but also by the collective. The diffusion process in developing agricultural communities is fundamentally equivalent to that of classical theory but with more emphasis being placed on the knowledge, persuasion, and decision components as needs by the adopters. Adoption rates in developing agricultural communities are influenced more heavily by social network and opinion leaders although external factors such as extension personnel can aid an innovation in achieving critical mass. Given the inherent risk of production agriculture and the agricultural producer's typical aversion to risk, the adopter categories tend to be skewed within the process in favor of fewer innovators in lieu of early and late majority adopters. Finally, relative advantage, compatibility, and complexity of the innovation itself have been found to be more visible, indicating a need

for greater transparency of the trialability and observability aspects of the innovation itself.

CHAPTER III

METHODS

This purpose of this chapter is to demonstrate the research design method, population and sample selection techniques, instrument, collection of data, and data analysis processes used to achieve the purpose of this study. The purpose of this study was to contribute to the body of knowledge surrounding the diffusion of information and technology among agricultural producers in developing countries. The objectives delineated to achieve the purpose of the study were:

1. Describe the adopter characteristics of agricultural producers in Brazil;
2. Describe the innovation traits that facilitate technology and information adoption in Brazil;
3. Describe agricultural innovation adoption processes in Brazil; and
4. Identify key elements and barriers of information transmission and adoption in Brazil.

Research Design

Research design methodologies utilized to achieve the objectives of the study were descriptive and correlational research. Descriptive research was utilized to provide insight into opinions, attitudes, and practices (Gall, Gall, & Borg, 2007) utilized currently in Brazil to disseminate innovations. Descriptive statistics used in the analysis included means, standard deviations, correlations, frequencies, and percentages. Correlational research was used to aid in describing the relationship between the

variables, enabling a more robust generalization of results (Tuckman, 1999). The research design allowed for the investigation of the existing variations in the variables based on the results of a survey instrument completed by agricultural producers in Brazil.

Population and Sample

The population for this study consisted of 3,289 agriculturists in the province of Rio Grande do Sul, Brazil. Rio Grande do Sul, Brazil was selected specifically for the characteristics of the agriculturist population in that province. The population was considered to be homogeneous in nature in that the socio-economic level did not vary significantly between individuals. The population was generally geographically dispersed and was rural in nature. Information sources for the population were largely centralized with the research stations which helped to control for informational asymmetries at the research level. The sample was selected based on agricultural cooperative meeting attendance in the Rio Grande do Sul province. A random sample of 369 individuals was selected based on respondent's characteristics. The target sample was 350 respondents. An additional 19 instruments were completed beyond the target. The sample was limited to agriculturists who utilized recognized emerging technologies and contemporary marketing techniques within the cooperative. Twenty-five surveys were submitted incomplete during the data collection process. The remaining 344 surveys constituted 10.4% of the target population.

Instrumentation

A questionnaire (Appendix A) consisting of nine constructs was administered for this study. The instrument used was derived from the proposed instrument of Moore and Benbasat (1991) evaluating the adoption of technological innovations. The instrument was not immediately suitable for the study of the target population as the instrument was not agriculturally focused. The instrument was subsequently amended to incorporate agricultural terminology while maintaining construct integrity. Advice on amending the final instrument was sought from faculty members at Texas A&M University, faculty members at South Dakota State University, and professionals involved in agricultural industry in the Rio Grande do Sul province of Brazil. Care was taken by the researcher to ensure clarity, purpose, and cultural awareness of the target population. The survey was translated from English into Portuguese by Global Speak Translations. The individual questions were constructed to minimize individual misinterpretation such that each individual would be able to interpret and accurately respond to all questions (Dillman, Smyth, & Christian, 2009).

The instrument used in this study consisted of eight attitudinal constructs and one demographic construct. Each attitudinal construct was measured on a five point Likert-type scale ranging from one to five. The scale for each construct was coded as follows: strongly disagree was coded as a value of "1," disagree was coded as a value of "2," neither agree nor disagree was coded with the value of "3," agree was assigned the value of "4," and strongly agree was coded to the value of "5." The resulting measurements collected from the attitudinal component of the instrument were collectively interpreted

as higher values being associated with more positive attitudes. Constructs were evaluated using directional statements consistent with the Tailored Design Method (Dillman et al., 2009). Negatively focused statements were reverse-coded to preserve data integrity. The attitudinal constructs measured by the instrument were voluntariness, relative advantage, compatibility, image, ease of use, result demonstrability, visibility, and trialability. There were four questions measuring the individual's attitude toward voluntariness. The relative advantage construct consisted of nine questions measuring the relative advantage attribute of the innovation. Compatibility was measured as a construct using four questions while the construct surrounding image was evaluated with five questions. Eight questions were presented on the instrument to address the ease of use construct and four questions were presented to address the demonstrability construct. The visibility and trialability constructs were each measured by five statements. The demographic component of the survey instrument addressed the demographics of the sample. The demographic construct collected data on age, education, profession, and gender. The purpose of the demographic questions was to aid in describing the aggregate sample and to assist in describing the characteristics of the individuals within the identified adopter categories.

Validity

Validity is an important element of research and is used to evaluate the ability of an instrument to measure its intended constructs appropriately (Gall et al., 2007). Validity consists of both internal and external validity. Internal validity represents the minimum standard for basic research to be considered appropriate. Eight variables have

been identified to impact internal validity including history, maturation, testing, instrumentation, statistical regression, selection, mortality, and selection-maturation interaction. An additional six variables were identified as potential threats to instrument validity. The variables relating to instrument validity were construct validity, face validity, content validity, concurrent validity, predictive validity, and consequential validity. The threats to internal validity were addressed in this study by several techniques. History was evaluated within the context of the study as the instrument was designed to measure participant perceptions. One component of perception was the participants' experience of past events which cause history to threaten the internal validity of the study. Maturation as a form of internal validity was addressed by collecting the data in the minimal amount of time to prevent maturation as a threat to internal validity. Participants were permitted only one response to the survey instrument thereby mitigating the testing element of internal validity. The threat to internal validity by instrumentation was not apparent as only one instrument was utilized for this study. To address statistical regression, the data was analyzed as one group. The threat internal validity posed by selection was minimized by the use of one grouping for analysis and sampling. Experimental mortality and selection-maturation threats were addressed by achieving data collection over a short period of time and the resulting analysis conducted as a single group.

Instrument validity was assessed based on construct, face, content, concurrent, predictive, and consequential validity. To handle construct validity, the individual statements for each construct were developed from an established instrument with

documented reliability measures. This was done to minimize the experimental design bias. As the purpose of the research was descriptive, threats from researcher expectations and the Hawthorne effect were considered to be minimal. Face validity was a concern as the target audience was not expected to have significant experience with research surrounding innovations. The context in which the instrument was administered at a technical trade show helped to minimize the threat of face validity. Content validity was another concern with the instrumentation. Content validity was minimized during the instrument development process by drawing on existing literature and instrumentation in order to refine the individual constructs. The constructs were refined to extract the maximum amount of data from each construct such that the aggregate instrument remained within the appropriate length parameters. Concurrent validity relates to the comparison between the performance of the instrument and some other concurrent measurement taken at the same time. Concurrent threats to instrumentation were considered to be minimal and were to be evaluated based on the comparison between the adopter and non-adopter groupings. As the research was descriptive and not predictive, predictive validity was not considered a danger to instrument validity. Consequential validity relates to the positive and negative social consequences to the administration of an instrument. With the goal of enhancing the adoption process which is a benefit to the participants, no negative social consequences were identified as a result of administering this instrument. As such, the threat of consequential validity to the instrument was considered to be minimized.

External validity is described as the ability to generalize the results of a study to a broader population. Threats to external validity encompass population validity and ecological validity. Population validity assesses the threats dealing with the general population while ecological validity evaluates the threats associated with the environment of the study. Ecological validity relates to the amount that the results from a study are influenced by the environmental conditions created by the researcher. Population validity in this study was managed by using a random sample drawn from the total study population. The sample data were analyzed to investigate statistical difference between early and later responders (Lindner, Murphy, & Briers, 2001). To establish the existence of differences between early and late responses one-way analysis of variance (ANOVA) and independent samples t-tests between the early and late response groups were utilized. The threats associated with ecological validity include the inability to replicate results, multiple treatment interference, the Hawthorne effect, disruption effects, researcher effect, pre-test sensitization, post-test sensitization, interaction effects, measurements effects, and time effects (Fraenkel & Wallen, 2009). The study design including large sample properties and a single use survey instrument served to minimize the threats to the ecological element of external validity in this study.

Reliability

The revised instrument was pilot tested in January 2017 using a sample of 33 agriculturists in Rio Grande do Sul, Brazil. The purpose of the pilot tests was to compare the initial reported measures of validity for the instrument to the calculated validity of the revised instrument. The instrument was further revised based on the

results of the reliability analysis. Reliability of each of the scales was evaluated using Cronbach's Alpha statistic to determine internal consistency. Reliability is a concept in research used to measure how well a specific instrument consistently produces similar results (Gall et al., 2007). Cronbach's Alpha is one of the most commonly used reliability measure in instrument-based research. Cronbach's Alpha reports the average correlation between all of the items on a given scale (Fraenkel & Wallen, 2009). Cronbach's Alpha levels above 0.7 are considered to be the minimum requirement for social science research (Nunnally, 1967). The reported Cronbach's Alphas for scales on the initial instrument were 0.9 for the relative advantage construct, 0.86 for the construct measuring compatibility, 0.84 for the ease of use construct, 0.79 for the demonstrability, 0.79 for the construct measuring image, 0.83 for the visibility construct, 0.71 for the trialability construct, and 0.82 for the construct measuring voluntariness (Moore & Benbasat, 1991).

Data Collection

Data collection for this study was conducted during February 2017 using a paper instrument. The paper questionnaire consisted of a multiple page book-fold instrument (Appendix A). The paper instrument used in this study was administered in adherence to the recommendations of the Tailored Design Method (Dillman et al., 2009). The instrument itself was administered by the researcher and a contracted data collection staff in cooperation with the Instituto Rio Grandense do Arroz (IRGA) in Rio Grande do Sul, Brazil. All interactions with respondents were conducted in a traditional face-to-face style. Participants were asked to review and sign an informed consent page

(Appendix B) that outlined the purpose of the research, provided the researcher's contact information and demonstrated the Internal Review Board (IRB) approval for the project. The instrument was completed after the informed consent form was completed by each participant.

Data Analysis

Data analysis for this research study consisted of coding and analysis by statistical software to obtain the descriptive and correlational statistics required to meet the objectives of the study. The coded data were entered into a Microsoft Excel 2010 spreadsheet and then uploaded and analyzed using the Statistical Package for Social Sciences (SPSS) version 21 for Microsoft Windows. The significance level for the descriptive and correlational statistics used in this study was established *a priori* at the 0.05 significance level. The 0.05 significance level is generally accepted as appropriate for statistical analysis in social science research (Fraenkel & Wallen, 2009; Gall et. al., 2007). Statistical measures used for this study included mean for measuring central tendency and standard deviation to measure the dispersion (Field, 2009). Categorical data was described using frequency and percentages. The interaction effect between variables was analyzed using regression analysis. Stepwise multiple regression analysis was also used to establish the relationships between the construct statements and the variables of the study. The stepwise regression method analyzed the amount of variance in the dependent variable explained by the independent variables (Gall, Gall, & Borg, 2007), which was one of the primary goals of the exploratory research. Principal component analyses are used primarily to explain the variance structure between

variables using linear combinations to achieve data reduction and improve data interpretation (Johnson & Wichern, 2007). Study constructs were measured on a Likert-type summated scale. The summated scale approach to construct measurement provided a basis for analysis to describe and draw inference from individual constructs.

Analysis of Data – Objective One

The first objective of this study was to describe the adopter characteristics of agricultural producers in Brazil. To accomplish this objective descriptive statistics such as mean, standard deviation, frequency, and percentage were used to describe the demographic characteristics of agricultural producers. Frequencies were used to describe rates of adoption of different types of innovations. Adopter classification was achieved by using mean, standard deviation, and frequency. Based on the analysis of the data the respondents were characterized into adopter categories. Categories were established based on the "S" shaped adopter curve posited by Rogers (2003). Demographic questions consisting of ordinal data and attitudinal questions on a five point Likert-type scale were used for categorization.

Analysis of Data – Objective Two

The second objective of this study sought to describe the innovation traits that facilitate or hinder the technology adoption decision in Brazil. Descriptive statistics were used to identify specific innovation characteristics associated with different innovation types. Mean and standard deviation characterized the specific characteristics as desirable or undesirable in an agricultural innovation. Data collected from the survey instrument containing constructs specific to innovation characteristics on a five-point

Likert-type response scale (*Strongly Disagree, Disagree, Neither Agree nor Disagree, Agree, Strongly Agree*) was used to classify the characteristics of innovations. The interpretation of the results was accomplished by analyzing the mean values of the constructs from the survey instrument specific to the innovation. Mean values greater than 4 indicated a positive characteristic while mean values between 2 and 3.9 indicated characteristics that were neutral or less desirable. Mean values lower than 1.9 were considered to be detrimental or undesirable innovation characteristics Regression analysis was performed on the data to examine the relationship between specific characteristics and successful innovation adoption. Factor analysis was performed on the variables to establish which characteristics contributed the most to innovation adoption.

Analysis of Data – Objective Three

The third objective of this study was to describe the agricultural innovation adoption process in Brazil. The results of the survey instrument were analyzed using a correlation analysis technique to determine the relationships between adopter categories, geographic location, and innovation specific characteristics. A stepwise regression analysis was also used to describe the adoption process based on the adopter categories and the innovation characteristics. The stepwise regression technique was selected for its ability to compare the individual statements from each construct and optimize the final model for explanatory power. The stepwise regression analysis was also able to evaluate the impacts that the identified statements had on the adopter category variables

in the study. The results of the correlation and regression analysis allowed the researcher to establish the nominal characteristics of the adopter curve for the sample.

Analysis of Data – Objective Four

The fourth objective of this study was to identify key elements of and barriers to agricultural technology adoption in Brazil. To accomplish this objective, constructs from the survey instrument evaluating perception were analyzed. The constructs were based on a five point Likert-type scale and investigated the perceptions of agricultural producers. Means in excess of 3.5 indicated agreement with the statement about the barrier or element of adoption while means between 2 and 3.4 indicated that the statement was neither a facilitator nor barrier to adoption. Mean values less than 1.9 indicated that the construct being evaluated was a barrier to adoption.

CHAPTER IV

RESEARCH FINDINGS AND DISCUSSION

The purpose of this study was to evaluate the level of information and technology diffusion in the agricultural sector of Rio Grande do Sul, Brazil. The objectives of this study were to

1. Describe the adopter characteristics of agricultural producers in Brazil;
2. Describe the innovation traits that facilitate technology and information adoption in Brazil;
3. Describe agricultural innovation adoption processes in Brazil; and
4. Identify key elements and barriers of information transmission and adoption in Brazil.

Demographic Profile of Participants

Analysis of the demographic data of the study population was accomplished by the application of descriptive statistics. The descriptive statistics were used to assist in understanding and interpreting the results of the research and its implications.

Twenty-two percent of the respondents in the study were female and 77% were male. One percent of the participants chose not to provide gender related demographic data. The mean age of the respondents in the study was 41 years old. The respondent's ages ranged from 17 to 75 years old. Eleven percent of participants opted not to report age related data. Respondents' ages were categorized into seven groups for reporting

purposes (Table 1). Seventy-seven percent of the study participants were between the ages of 25 and 64 years old.

Table 1

Respondent's Ages (n=344)

Age	*f*	*%*
Under 25 years of age	31	9.3
25 to 34 years of age	80	24.0
35 to 44 years of age	70	21.0
45 to 54 years of age	64	19.2
55 to 64 years of age	44	13.2
65 years of age and older	10	3.0
Missing Data	35	10.5

Note: M = 40.9; SD = 13.2

Participants' educational levels ranged from respondents with no formal education to respondents who had completed post-graduate degree programs (Table 2). The largest group (31.1%) reported having completed high school as the highest education achieved, while 39.8% of all participants reported having completed a bachelor's or post-graduate degree. Seven participants chose not to report education related data.

Table 2

Highest Educational Level of Participants (n=327)

Educational Level	*f*	*%*
No Formal Education	15	4.5
Primary School	43	12.9
High School Diploma	104	31.1
Some College Courses	32	9.6
Bachelor's Degree	91	27.2
Postgraduate Degree	42	12.6

Data profiling respondents' professional occupations was also collected. 40.1% of respondents were farmers and 37.1% were employed in related agricultural industries. 53 respondents (15.9%) were classified as other professions while fourteen respondents (4.2%) were classified as marketers (Table 3).

Table 3

Occupations of Respondents (n=325)

Occupation	*f*	*%*
Farming	134	40.1
Agricultural Industry	124	37.1
Other Agricultural	53	15.9
Marketer	14	4.2

Research Findings for Objective One

The first research objective of this study was to describe the adopter characteristics of agriculturists in Rio Grande do Sul, Brazil. Adopters were characterized by their willingness to try agricultural technology voluntarily, a high perception of the relative advantage of an innovation, strong compatibility between the innovation and the individual's lifestyle, stronger perception of image associated with using an innovation, being readily able to use new innovations, being readily able to grasp the use of new innovations, easily perceiving new innovations in their environment, and the individual's positive perception about trying new innovations. Of the study's participants, 41 individuals (12.3%) met the criterion for adopter while 291 participants (87.7%) were classified as non-adopters. Within the classified adopter category, 87.8% of adopters were identified as being male while 12.2% of adopters were female. The predominant adopter age group was 25 to 34 years old, but a majority

(51.2%) of the adopters was 45 years old or older. Adopter age demographics are shown in Table 4.

Table 4

Adopter's Ages (n=41)

Age	*f*	*%*
Under 25 years of age	1	2.4
25 to 34 years of age	12	29.3
35 to 44 years of age	6	14.6
45 to 54 years of age	10	24.4
55 to 64 years of age	10	24.4
65 years of age and older	1	2.4
Missing Data	1	2.4

Note: M = 44.7; SD = 13.3

Adopters were found to be educated with 85.3% having completed high school, with 51.2% of adopters reported having completed an undergraduate degree or some college coursework. Moreover, 14.6% of adopters had attained a post-graduate degree or higher education. Table 5 reports the educational achievement levels of adopters.

Table 5

Highest Educational Level of Adopters (n=41)

Education	*F*	*%*
No Education	2	4.9
Grade School	4	9.8
High School	8	19.5
Some College Courses	5	12.2
Undergraduate Degree	16	39.0
Graduate Education	6	14.6

Voluntariness of the adopters was the first construct evaluated. The purpose of the voluntariness construct was to evaluate the degree to which the individual did or did not actively seek out an innovation. The voluntariness construct also measured involuntary factors through specific statements in order to gain further knowledge about that particular aspect of the adoption decision. When asked about the use of technology in their daily lives, participants classified as adopters responded with strong affirmation. Adopters' perceptions of required use of technology by their peers had the greatest impact on adoption with a mean value of 4.61. The voluntary use of technology to locate price information also had a large impact on adoption with a mean value of 4.54. Table 6 demonstrates the ranked characteristics of adopters under the construct of voluntariness.

Table 6

Indicators of Adopters' Voluntariness (n=41)

Characteristic	*M*	*SD*
My peers expect me to use technology	4.61	.49
I use technology voluntarily	4.54	.50
Technology is useful but not required	4.39	.49
My job requires use of technology	4.34	.53

Note: M = 4.47, SD = 0.51, 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree

Relative advantage was the second trait that by which adopters were characterized. Adopters reported a strong belief (M = 4.63, SD = .48) that technology was beneficial in helping to accomplish tasks more frequently. Participants in the adopter category also indicated that technology made their jobs easier (M = 4.63, SD = .48). Increases in productivity as a result of technology innovation use (M = 4.56, SD = .50) was a perception of adopters as well. Table 7 summarizes the characteristics of adopters for the construct of relative advantage.

Table 7

Indicators of Adopters' Perception of Relative Advantage of the Innovation (n=41)

Statement	*M*	*SD*
Technological innovations enable more rapid task completion	4.63	.49
Technology makes my job easier	4.63	.49
Technology increases my productivity	4.56	.50
Technology improves performance	4.49	.51
Innovative technology improves my quality of work	4.46	.60
Innovations makes me more effective at my job	4.44	.50
Innovations allow me more control over output	4.39	.49
Using innovations daily are advantageous to me	3.2	1.44

Note: M = 4.35, SD = 0.82,1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree

The compatibility of a perceived innovation with an adopter's lifestyle was measured and reported. Individuals categorized as adopters reported that innovative technology fit well with their own personal work habits (M = 4.37, SD = .48). Participants in the adopter category also gave positive responses that innovative technology fit well within the demands of their jobs, lifestyles, and professional goals. Table 8 outlines the adopter profile from the standpoint of compatibility.

Table 8

Characteristics of Adopters' Perception of the Compatibility of Innovations (n=41)

Characteristic	*M*	*SD*
I believe that technology fits well with my work style	4.37	.49
Using technology is compatible with my job	4.29	.56
Using technology is compatible with my lifestyle	4.20	.56
Using technology is compatible with my professional goals	4.20	.72

Note: M = 4.26, SD = 0.59, 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree

Personal image was another area in which adopters were evaluated. Image related as to how the individual was perceived by others and themselves when using an innovation. Participants categorized as adopters generally felt that the use of innovative agricultural technology within their daily life increased their perceived image among their peers (M = 4.29, SD = .642). Adopters also believed strongly that their use of agricultural technology was a symbol of status in their community. Table 9 describes the attitudes of adopters regarding image.

Table 9

Characteristics of Adopters' Perception of Image (n=41)

Statement	*M*	*SD*
Technology use improves my image among my peers	4.29	.64
Technology use raises my status in my community	4.22	.42
Peers using technology have a higher status than others	4.02	.57
I am perceived as having more value by using technology	4.02	.65

Note: M = 4.14, SD = 0.58. 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree

A fifth construct by which adopters were described was how easy to use they felt that agricultural technology actually was. Individuals displaying adopter characteristics indicated that learning how to use a new technology or innovation was easy for them to accomplish (M = 4.29, SD = .46). Adopters also indicated that continued use of the technology was also easy to accomplish (M = 4.24, SD = .734). Adopters generally indicated that new innovations and technology were easy for them to both use and retain. Table 10 provides an overview of the adopters' responses to the various components measured within the construct.

Table 10

Statements to Indicate Adopters' Perceptions of Ease of Use of Innovations (n=41)

Statement	*M*	*SD*
Technological innovations enable more rapid task completion	4.29	.46
Technology makes my job easier	4.24	.73
Technology increases my productivity	4.20	.40
Technology improves performance	4.15	.53
Innovative technology improves my quality of work	4.07	.61
Innovations makes me more effective at my job	3.25	1.15
Innovations allow me more control over output	3.13	1.20
Using innovations daily are advantageous to me	3.00	1.14

Note: M = 3.79, SD = 0.98. 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree

Respondents were further evaluated based on their perception of result demonstrability of a technology. Classified adopters responded strongly (M = 4.34, SD = .48) that the results of using agricultural technologies were readily apparent to them. Adopters also reported a confidence in being able to communicate the results of using agricultural technology to locate price information (M = 4.2, SD = .67). The adopters' responses for all of the measured elements of the construct are reported in Table 11.

Table 11

Statements to Indicate Adopters' Perception of Result Demonstrability (n=41)

Statement	*M*	*SD*
The results of using agricultural technology are apparent	4.34	.48
I can communicate the results of technology use easily	4.20	.64
It is easy to show others the benefits of using agricultural technology	4.20	.68
I can easily communicate the benefits of technology to others	3.22	.11

Note: M = 3.99, SD = 0.87. 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree

Visibility of innovations was the seventh construct about which respondents were queried. Participants classified as adopters responded strongly in favor of their regularly using agricultural technology (M = 4.34, SD = .48). Adopters were also able to spot technologies being employed in other places outside of their individual operation (M = 4.32, SD = .521). Table 12 summarizes the findings of the adopters' perceptions of visibility of technology.

Table 12

Statements to Indicate Adopters' Perception of Visibility (n=41)

Statement	*M*	*SD*
I have seen other use agricultural technology	4.34	.48
I can observe agricultural technologies in other locations	4.32	.52
New technology is used widely in my community	4.29	.51
It is easy to observe new technologies being implemented	4.20	.40

Note: M = 4.29, SD = 0.48. 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree

The final construct that participants responded to was that of trialability. When asked about the decision making process of whether to adopt a technology, participants classified as adopters indicated that they strongly preferred to try out the new technology first (M = 4.2, SD = .40). Respondents also indicated that they were confident in knowing where to go to locate new innovative technologies (M = 4.15, SD = .62). The findings for each of the elements of the construct are presented in Table 13.

Table 13

Characteristics of Adopters' Perception of Trialability (n=41)

Characteristic	*M*	*SD*
I try out new technologies before using them	4.20	.724
I know where to look to evaluate new technologies	4.15	.622
I try new technologies until I am comfortable using them	4.07	.685
I test applications on a new technology before adopting	4.02	.724
There are many opportunities to try out new technologies	3.93	.755

Note: M = 4.07, SD = 0.65. 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree

Research Findings for Objective Two

The second objective of the study was to describe the specific traits of innovations that enhance the adoption process in Brazil. To accomplish the identification of the innovative traits, I used the descriptive characteristics and responses of participants. Mean values greater than 4.0 were indicative of positive traits. Traits with mean values between 2 and 3.9 were indicative of neutral or less desirable traits. Traits with mean values less than 1.9 indicated traits negative to the adoption process. Frequencies were used to evaluate the magnitude of each element of the construct represented. Innovation traits were evaluated based on each of the 8 constructs measured in the survey instrument.

The first construct evaluated for adoption traits was voluntariness. There were 4 statements within the construct that measured the expectation of use, the voluntariness of use, the requirement of use, and the perceived usefulness of an innovative technology. The statements "I am not required to use technology as part of my job" and "Technology is helpful performing my job" were reverse coded to minimize acquiescence and inattention problems. As shown in Table 14, respondents indicated that the expectation of use led to the strongest influence of the voluntariness component of adoption (M = 4.34, SD = .552). The requirement of use, voluntariness of use and perceived usefulness were all considered to be positive traits for adoption with means in excess of 4.0. The requirement of use was reported by respondents to have the most magnitude with regard to contributing to the adoption of an innovation with over ninety-five percent of participants responding with "agree" or "strongly agree." Ninety-seven percent of respondents indicated that expectation of use influenced their decision to adopt indicating that job requirement and peer pressure are significant measures of voluntariness.

Table 14

Measures of Innovation Voluntariness (n=334)

Characteristic	*f*	*%*	*M*	*SD*
Expectation of use	319	95.5	4.34	.55
Voluntariness of use	319	95.5	4.29	.52
Perceived usefulness of innovation	318	95.2	4.27	.53
Requirement of use	319	95.5	4.26	.52

Note: M = 4.29, SD = 0.53, Cronbach's Alpha = 0.77. 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree

Relative advantage was the second innovative trait analyzed. Relative advantage was measured based on participants' responses to statements about whether the innovation was perceived to accomplish tasks faster, produce higher quality work, make work easier, simplify lifestyle, increase overall job performance, make the individual a better employee, be more versatile, and increase productivity. Participants indicated that innovations with characteristics that make work easier are the most attractive innovations (M = 4.34, SD = .65). Innovations that produce higher quality work, help to accomplish tasks faster, increase job performance, increase productivity, make for a better employee, and improve versatility were all considered to be positive traits with mean values greater than 4.0. Lifestyle simplifying characteristics in innovations were indicated to be neutral as opposed to a positive trait (M = 3.42, SD = 1.28). To evaluate the impact of the neutral statement relating to simplifying the lifestyle, an additional

reliability analyses was conducted on the relative advantage construct with the statement relating to simplifying lifestyle excluded from the analysis. The exclusion of the statement increased the reliability measure of the construct from 0.82 to 0.89. Table 15 summarizes the attitudes of the respondents to different statements of dimensions relating to relative advantage. Most respondents indicated that innovations with characteristics that made their lives easier was their preference with ninety-three percent selecting “agree” or “strongly agree”.

Table 15

Measures of Innovation Relative Advantage (n=334)

Characteristic	*f*	*%*	*M*	*SD*
Make work easier	309	93.1	4.34	.65
Produce higher quality work	306	91.6	4.33	.69
Accomplished tasks faster	308	92.2	4.32	.71
Increase job performance	308	92.2	4.24	.65
Increase productivity	293	97.7	4.21	.69
Make the individual a better employee	301	90.1	4.18	.66
Improve versatility	299	89.5	4.13	.66
Simplify lifestyle	186	55.7	3.42	1.29

Note: M = 4.15, SD = 0.82, Cronbach’s Alpha = 0.82. 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree

Compatibility was the third construct analyzed to determine innovative traits that facilitate adoption. The compatibility construct was assessed based on participant responses to statements reflecting the degree to which innovations were perceived to be compatible with the individual's work requirements, to integrate into existing personal lifestyle, to integrate well with work preferences, and to integrate well with work style. Respondents noted that the ability to fit into the individual's work preferences was the strongest measured characteristic of compatibility ($M = 3.9$, $SD = .77$). The means of all of the measured elements of the construct fell between 2.0 and 3.9 with less than eighty percent of respondents responding "agree" or "strongly agree" to any measurements internal to the construct. The results suggest that the measured component traits of innovation compatibility were neutral or less desirable. Seventy-seven percent of respondents indicated that the ability of an innovation to fit into the individual's work preferences followed by the ability to integrate into the individual's existing personal lifestyle as shown in Table 16.

Table 16

Measures of Innovation Compatibility (n=334)

Characteristic	*f*	*%*	*M*	*SD*
Fits well with work requirements	256	76.7	3.90	.77
Integrates well with work style	243	72.8	3.86	.76
Fits with existing personal lifestyle	247	74.0	3.84	.77
Compatible with work requirements	237	71.0	3.75	.87

Note: M = 3.84, SD = 0.80, Cronbach's Alpha = 0.82. 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree

The fourth construct to measure the innovative traits that facilitate adoption was image. The construct was evaluated based on respondents' perception of how image is impacted by use of the innovation. Four statements about image were used to measure this construct. The statements measured the participants' perception as to whether the innovation increased their personal self-image, whether the innovation increased others' perception of the user, whether the users were perceived to have greater value through use, and whether the use of an innovation was considered a status symbol. Of the measured elements of the construct, the perception that the innovation increased the personal self-image was the image attribute that had the greatest impact on the innovation adoption decision (M = 3.76, SD = .78) followed by the perception that users were perceived to have a greater value by using the innovation (M = 3.32, SD = .99). All of the elements were classified as neutral to less desirable innovation traits with

means ranging from 3.26 to 3.76 as shown in Table 17. The perception that the use of innovations boosted self-image was the most widely held belief among the study population with sixty-seven percent of the sample responding with "agree" or "strongly agree." Over half of the respondents responded negatively with "strongly disagree," "disagree," or "neither agree nor disagree" to the measurements of whether innovation use increased others' perception of the user, that by use the user gained greater value, or that the use of innovations added to personal social status.

Table 17

Elements of Perceptions About Innovations' Effects on Image (n=334)

Characteristic	*f*	*%*	*M*	*SD*
Innovation increases self-image	225	67.4	3.76	.79
User gains greater social value	159	47.6	3.32	.99
Peer perception and recognition increased	145	43.4	3.28	.97
Innovation use is a status symbol	146	43.7	3.26	.99

Note: M = 3.41, SD = 0.96, Cronbach's Alpha = 0.81. 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree

Ease of use was analyzed as a construct to determine which components contributed most to innovation adoption. The ease of use construct was measured by participant responses to specific statements. The specific statements measured participant perception about whether the use of the innovation is transparent, whether the innovation process is simple to remember, the ease at which the innovation is to learn

and master, how easy the innovation is to manipulate, the overall ease with which the innovation can be used, the complexity of the innovation itself, the consistency with which the innovation can be applied, and the ability of the innovation to be used habitually. Innovation transparency was reported as the most important attribute by participants (M = 3.79, SD = .70) followed by the ease which the innovation's procedural use is to remember (M = 3.74, SD = .74). All of the measured elements were judged to be neutral or less desirable traits to facilitate adoption by the participants. Seventy-five percent of respondents indicated that transparency of use was of importance as illustrated in Table 18. Consistency of use and ease of habitual use were found to have the least amount of importance among respondents with less than fifty percent of participants indicating a response of "agree" or "strongly agree."

Table 18

Measures of Innovation Ease of Use (n=334)

Characteristic	*f*	*%*	*M*	*SD*
Innovation use is transparent	250	74.9	3.79	.702
Process is simple to remember	234	70.1	3.74	.746
Innovation/process is easy to learn	231	69.2	3.72	.820
Innovation is easy to manipulate	237	71	3.71	.702
Innovation is easy to use	220	65.9	3.69	.815
Innovation is not complex	186	55.7	3.39	1.026
Innovation is consistent and seamless	164	49.1	3.27	.995
Innovation use is habitual	152	45.5	3.21	1.004

Note: M = 3.57, SD = 0.89. 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree

The sixth construct analyzed for dissemination attributes was result demonstrability. Result demonstrability was measured through statements that reflected the participant's perceptions as to how easy the innovation was to learn or demonstrate to others, the ease with which the innovation can be communicated to others, how readily apparent the results were to the user, and how obvious the benefits of user were. Survey respondents' indicated that readily apparent results were the most important attribute of result demonstrability (M = 3.89, SD = .73) with seventy-nine percent of participants indicating "agree" or "strongly agree" for that measure. Each of the four

measured attributes were found to be neutral or less desirable innovation traits as shown in Table 19. Obvious benefits to the user was found to be the least important attribute (M = 3.33, SD = 1.004) with less than fifty-four percent of participants responding with "agree" or "strongly agree".

Table 19

Measures of Innovation Result Demonstrability (n=334)

Characteristic	*f*	*%*	*M*	*SD*
Readily apparent results	262	78.5	3.89	.725
Ease of communicating to others	252	75.5	3.83	.775
Ease of learning or demonstrating to others	236	70.7	3.75	.789
Obvious benefits to the user	180	53.9	3.33	1.004

Note: M = 3.70, SD = 0.86. 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree

Visibility was the seventh attribute of innovations evaluated in the study. The visibility construct was analyzed based on four statements about individual perceptions of visibility. The statements upon which the construct was measured were the visibility of peers using agricultural innovations, the obvious versatility of applying agricultural technologies, the commonality of use in other working environments, and the obvious usage within the individual's community. When asked about the visibility of peers using agricultural innovations (M = 4.07, SD = .59), ninety percent of respondents answered

"agree" or "strongly agree". Study participants also indicated that it was common to see technological innovations being used in the business operations of others (M = 4.01, SD = .68). The measurement variables of peer usage and visibility in others business operations were found to be the only two positive attributes measured under the construct. The apparent versatility of the innovation and obvious usage in the individual's community were found to neutral or less desirable attributes. Table 20 summarizes the results of the visibility construct.

Table 20

Measures of Innovation Visibility (n=334)

Characteristic	*f*	*%*	*M*	*SD*
Peer usage of innovation is obvious	299	89.6	4.07	.592
Visibly used in other's work environments	274	82.1	4.01	.684
Innovation is obviously versatile	260	77.9	3.94	.660
Communal use of innovation	206	61.7	3.58	.845

Note: M = 3.90, SD = 0.73. 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree

The eighth and final construct analyzed for innovation attributes was trialability. Five statements of trialability were measured. The measurements included exposure to new and emerging technologies, the ease at which new technologies could be sought out, the availability of new technologies once located, the ability of the individual to test out

new technologies at their leisure, and the sufficiency of the length of trial period for the innovation. When asked about the ease of personally locating new innovations sixty-two percent of respondents indicated agreement or strong agreement (M = 3.56, SD = 8.6). Respondents also noted that there was sufficient exposure to new technologies (M = 3.44, SD = .94). As shown in table 21, none of the five measurements of the trialability construct were found to be positive. Less than half of respondents indicated agreement or strong agreement that trial period length or availability or the ability to use previously located technologies was sufficient.

Table 21

Measures of Innovation Trialabilty (n=334)

Characteristic	*f*	*%*	*M*	*SD*
Ease of personally locating new innovations	208	62.3	3.56	.86
Exposure to new technologies	186	55.7	3.44	.94
Sufficient trial period length	162	48.5	3.30	.93
Availability of using located technologies	152	45.5	3.30	.93
Trial period availability	148	44.3	3.27	.93

Note: M = 3.37, SD = 0.92, Cronbach's Alpha = 0.70. 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree, 5 = Strongly Agree

Research Findings for Objective Three

The third research objective of this study was to describe the agricultural innovation adoption process in Rio Grande do Sul, Brazil. To accomplish this, survey participants were first classified into the innovator, early adopter, early majority, late majority, and laggard adopter categories by utilizing the responses to elements from each of the eight measured constructs. This classification process was conducted to identify the group traits that are specific to each classification of adopter. Voluntariness was measured by whether the respondent used innovations voluntarily. The relative advantage construct was measured by how much technology was perceived to make work easier while the compatibility construct was measured by how well innovations integrated into the respondents work environment. Image was evaluated based on the response to whether the innovation use was considered a status symbol by the participants and ease of use by whether an innovation was perceived as easy to manipulate. The result demonstrability and visibility construct were evaluated against the perception of how readily apparent results were and how easy it was to observe the use of an innovation within the individual community respectively. The trialability construct was evaluated by the individual's perceived ability to test out the innovation. Respondents responding "strongly agree" to each of the eight traits/characteristics were classified as innovators. Participants answering "agree" or "strongly agree" to all of the measurements, excluding those individuals classified as innovators, were classified as early adopters. Individuals reporting "neither agree nor disagree", "agree", or "strongly agree with all eight measurements but were not classified as innovators or early adopters

were categorized as members of the early majority. The participants answering "disagree", "neither agree nor disagree", "agree", or "strongly agree" to each of the measurements but were not previously classified as innovators, early adopters, or early majority were identified as members of the late majority adopter group. All remaining study participants were classified as laggards. The results of the classification are reported in Table 22.

Table 22

Adopter Category Classification

Category	*f*	*%*
Innovators	1	0.3
Early Adopters	40	12.0
Early Majority	101	30.2
Late Majority	135	40.4
Laggards	17	5.1

Following the adopter classification, a stepwise multiple regression analysis was performed. The analysis was conducted to determine which construct elements contributed significantly to the categorization of adopters within the innovation process. The adopter category was the dependent variable with the 45 measured elements of voluntariness, relative advantage, compatibility, image, ease of use, result

demonstrability, visibility and trialability representing the independent variables in the analysis.

The results of the stepwise regression model indicated that nine of the 45 measured statements across all eight of the constructs explained 58.6% of the variation in the model. The identified constructs were "My peers expect me to use technology" as a measure of voluntariness, "Using technological innovations increases my productivity" measured as a component of relative advantage, "Using agricultural technology suits my work style" and "Using agricultural technology is compatible with all aspects of my work" measuring compatibility, "Using agricultural technology is a status symbol in my community" as measurement of image, "Agricultural technology is easy to manipulate" as a measure of ease of use, "Agricultural technology is easy to communicate" as a measurement of result demonstrability, "It is easy to observe others using agricultural technology in my community" as a measurement of visibility, and "I was able to properly try out an agricultural technology prior to use" as a measurement of trialability. The output from the stepwise regression model suggested that the innovation adoption category was influenced toward greater degrees of adoption as peer pressure to use innovations mounted on the individual. The stronger belief that innovations increased productivity and suited the individuals work style was also noted to enhance the degree of adopter category as was the compatibility of the innovation with the individual's work, the perception of using technology as a status symbol, the perception that technology is easy to manipulate, observing others in the community using technology, the ability to easily communicate technology, and the ability to properly test a new

innovation were found to enhance the adoption process. Difficulties in seeing the immediate results in a technology were found to transition the individual adopter category toward the laggard category and thus impede the adoption process. The measurements of voluntariness, image, result demonstrability, visibility, and trialability were all significant at the five percent level. The measurements of relative advantage, compatibility, and ease of use were not statistically significant predictors of innovator characterization. Table 23 outlines the results of the model.

Table 23

Identified Constructs Relating to Innovation Adoption

Independent Variables	*Beta*	*t*	*p*
My peers expect me to use technology	-.099	-2.29	.03
Using innovations increases my productivity	-.005	-.10	.92
Using agricultural technology suits my work style	-.016	-.32	.75
Using technology is compatible with my work	-.075	-1.59	.11
Technology is a status symbol in my community	-.543	-12.74	.00
Agricultural technology is easy to manipulate	-.070	-1.59	.11
Agricultural technology is easy to communicate	.123	2.70	.01
It is easy to observe others using technology in my community	-.223	-5.16	.00
I was able to test a technology prior to use	-.295	-6.63	.00

Note: Model $R^2 = .586$, $F = 41.544$

Research Findings for Objective Four

The fourth objective of the research was to identify the key elements and barriers of information transmission and adoption in Brazil. To identify the barriers to transmission, the construct elements that characterized non-adoption were analyzed using stepwise regression. The stepwise regression used a dummy variable for adopter type as the dependent variable where adopters were identified with a value of one and non-adopters were identified by a value of zero. The elements of each construct within the survey instrument were used as the independent variables in the model. The identified construct elements that most significantly impacted adoption were then used to characterize the components of innovations that contributed to the adoption process.

The model included the voluntariness construct measurement of "my peers expect me to use technology". All other measured elements of the voluntariness construct were excluded from the model. The relative advantage construct measurements of "technology allows me to increase productivity" and "technology simplifies my lifestyle" were the only measures of relative advantage included in the model. The measured constructs of "using technology fits my work style" and "using new technology is a status symbol" were included for compatibility and image in the model respectively. The ease of use construct contributed "new innovations are easy to learn", new technologies are not complicated to understand", and "new technology is easy to manipulate" to the model. Within the construct of visibility, the measurement "innovations are easy to see in my community" was included as was the measured trialability construct of "the trial period for new technologies is sufficient". All

remaining measurements of the voluntariness, relative advantage, compatibility, image, ease of use, visibility, and trialability were excluded from the model. The construct for demonstrability was excluded entirely from the model's results. The construct measurements included in the model explained 36.1% of the variation in the adopter classification. The construct measurement for image "using new technology is a status symbol", the construct measurement for ease of use "new technologies are complicated", the visibility construct measurement "It is easy for me to observe others using agricultural technologies in my community", and the construct measurement of trialability "Before deciding whether to use agricultural technologies for finding price information, I was able to properly try them out" were the only statistically significant variables at the five percent level. **T**he model's results suggest that peer expectation to use technology contributes positively to the adoption of an innovation. Innovations that increased productivity, increased status, were easy to learn, were easy to manipulate, visible in the community and had a sufficient trial period were determined to contribute to the adoption process. Conversely, innovations that only simplified lifestyle, only simplified work style, and were complicated to learn did not contribute to the adoption process and were viewed as barriers. The results of the model were interpreted as a one unit increase in the measured construct would increase the likelihood of adoption by the respective beta coefficient of that measured construct. For example, a one unit increase in the perception that peers expected the use of technology resulted in a .058 increase in the likelihood of the innovation being adopted. The results of the model are noted in Table 24.

Table 24

Identified Constructs Relating to Adopter Characteristics

Independent Variables	*Beta*	*t*	*p*
My peers expect me to use technology	.058	1.569	.118
Technology allows me to increase productivity	.023	.795	.427
Technology simplifies my lifestyle	-.020	-1.442	.151
Using technology fits my work style	-.015	-.528	.598
Using new technology is a status symbol	.110	5.881	.000
New innovations are easy to learn	.045	1.740	.083
New technologies are complicated	-.053	-2.804	.005
New technology is easy to manipulate	.022	.840	.401
Innovations are easy to see in my community	.071	3.128	.002
The trial period for new technologies is sufficient	.107	5.058	.000

Note: Model $R^2 = .361$, $F = 15.639$

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Problem Statement

Agricultural producers in developing countries experience significant disadvantage to their counterparts in more developed countries. Specific among the disadvantages are barriers to technological and information exchange (Godfray, et al., 2010). Poor communication and lower levels of education contribute to the inability for information and technology to be disseminated (Dutta, 2009). Theories suggesting optimal information dissemination methods to agriculturists in developing countries have been presented but no single optimal theory has yet been identified. (Wellard, Rafanomezana, Nyirenda, Okotel, & Subbey, 2012). Better understanding of the factors specific to developing countries is necessary in order for researchers to increase the efficacy of information dissemination (Quaim, 2005).

Purpose and Objectives of the Study

The purpose of this study was to evaluate the level of information and technology diffusion in the agricultural sector of Rio Grande do Sul, Brazil. The objectives of this study were:

1. Describe the adopter characteristics of agricultural producers in Brazil;
2. Describe the innovation traits that facilitate technology and information adoption in Brazil;
3. Describe agricultural innovation adoption processes in Brazil; and

4. Identify key elements and barriers of information transmission and adoption in Brazil.

The results of this study are important to multiple industry participants and stakeholders in Rio Grande do Sul, Brazil. Stakeholders include academia, industry, and agriculturists. The findings of this study are useful for organizations attempting to communicate more directly and efficiently with farmers. Industry participants' trying to utilize a more effective and efficient means of relaying technological innovations to producers will be particularly impacted.

Summary of Methods

To conduct this study I selected a random sample of 369 agriculturists from Rio Grande do Sul, Brazil based on participation in an annual farm conference. I contacted the sample members and asked them to complete a paper based questionnaire as suggested by Dillman (2007). The participants were given the opportunity to opt out of the research at any point.

The survey instrument consisted of 45 individual questions spanning eight attitudinal constructs and a section on demographics. The attitudinal constructs measured were voluntariness, relative advantage, compatibility, image, ease of use, result demonstrability, visibility, and trialability. The demographic section collected age, sex, and educational attainment.

I collected 369 questionnaires from respondents; that is, each sample member returned his/her questionnaire. Twenty five of the questionnaires were incomplete. The 344 completed questionnaires represented responses of 10.4% of the target population.

Descriptive statistics (mean, median, standard deviations, percentages and frequencies) were used to analyze the data. Stepwise linear regression techniques were used to analyze the constructs to determine which components most influenced the adoption process and adopter categories. Reliability measures for the study were calculated using Cronbach's alpha with a minimum threshold of .70 necessary for the construct to meet the required rigor. The alpha threshold for statistical significance was established *a priori* at the .05 level. Data analysis was conducted using the Statistical Package for Social Sciences (SPSS) software program version 21.0.

Participant Demographics

Seventy-seven percent of the respondents were male. Forty-five percent of respondents were between the ages of 25 and 44 with a mean age of 40.9 years old. Thirty-one percent of the respondents had completed high school, with another 27.2& of respondents reporting having completed an undergraduate degree. Forty percent of the participants were directly engaged in production agriculture while an additional 37.1% of respondents were employed by a related industry. All of the respondents were located in the province of Rio Grande do Sul, Brazil.

Research Objective One

The first objective of this research was to describe the adopter characteristics of agricultural producers in Brazil.

The study determined that measures of voluntariness most impacting the decisions of individuals classified adopters were the degree to which peers expected the individual to use technology, to what degree the individual would voluntarily use

technology, how useful the technology was to the individual, and whether the individual was required to utilize technology to locate information. This combination of characteristics suggests that a combination of optional innovation adoption decisions, collective innovation adoption decisions, and authority innovation adoption decisions (Rogers, 2003) are used during the adoption process. As posited by Rogers (2003), these decisions are not demonstrated to be mutually exclusive. Adopters were generally characterized with higher levels of engagement than their non-adopter counterparts. The results of this study suggest that higher levels of education contribute to greater adoption rates in developing countries. Individuals that experienced peer pressure as a requirement to use a technology were more likely to become adopters themselves. As a component of voluntariness this finding indicates that both individual and collective innovation decision making are predominant in Rio Grande do Sul, Brazil. Individuals identified as adopters were also more likely to utilize technology voluntarily and note its usefulness on their own initiative. Within the voluntariness construct, adopters can be described as engaged and actively looking for new technologies as well as recognizing the utility of working with peers to improve performance. The adopter characteristics identified in the results of this study also indicate that the individual adopters are more likely to be opinion leaders Rogers (2003).

Measures of relative advantage that describe the innovation adopter most effectively were those individuals who were adept at using technology to accomplish tasks more quickly. Those individuals were more likely to understand the application of the innovation in order to leverage their time to greater efficiencies. Adopters were also

able to recognize the ability of new innovations to simplify their jobs. Adopters were able to increase their productivity and job performance by using new technology to a higher degree than their non-adopter counterparts. These measures of relative advantage are consistent with the findings of Koundouri, et al. (2006) that perceived benefits of economic profits facilitate adoption, particularly when economic profits are viewed as increased disposable time or energy. The context of these findings is consistent with gains in time and energy (Green, Mas-Colell, & Whinston, 1995). By the measures of relative advantage, adopters can readily be described as individuals who appreciate faster, higher quality work. These individuals are also likely to leverage technology and innovation from their work environment that leads to a more productive, simple, and versatile personal life. The characteristics of adopters for relative advantage in this research were consistent with Rogers' (2003) findings that relative advantage can be expressed in both economic and social terms. Under the relative advantage construct classified adopters were also consistent with Rogers' (2003) definition of innovators by being able to quickly grasp the benefit of a technology and understand its complexity. The work of James (2005) was also supported in that the blending of information sources from work and personal environments enhanced the adoption process.

The compatibility element of adopters was best characterized as an individual who saw innovations as completely compatible with both work and personal lifestyle and that enhanced the ability of the individual's preferred style of completing tasks. This element of the adopter's description would be indicated by an individual who is able to seamlessly apply innovations from their professional life to their personal life and

vice-versa. The results of the study suggest that adopters in Rio Grande do Sul are more perceptive to innovation adoption based on its compatibility with the individual's needs as opposed to beliefs or previously-introduced ideas (Rogers, 2003).

Adopters were also described based on an image construct. Adopters place a high value on status. Innovations that elevate public image and status in the community as well as enhancing the self-image of the adopter will see a greater degree of adoption. Adopters can be described from an image standpoint as those individuals who seek higher social status and associate the use of new technology as a symbol of that status. These individuals are likely to be well informed as compared to their social counterparts and will also likely value aesthetics as well as functionality. This result is consistent with Young's (2009) finding that individuals are more likely to adopt innovations that are highly acceptable within the individual's social context.

Ease of use for the adopter was another component of the adopter profile. Adopters were less concerned with the complexity of an innovation than non-adopters. Similarly adopters were not as impacted by new technologies that were difficult to learn or required significant thought to operate. Adopters were able to learn how to use the technology more rapidly and also found new technologies relatively easy to manipulate once the process had been taught. From the ease of use dimension, adopters can be described as individuals who are able to utilize their existing knowledge of technologies and apply it in principle to a new innovation. These individuals will also be more likely to attempt more complex applications of new innovations even if it requires a significant amount of thought to accomplish. The results of this research suggest that while

adopters are willing and able to try new and more complex innovations, non-adopters are less likely to do so. This finding is consistent with the generalization that the complexity of an innovation is inversely related to the rate of adoption. The results also support the general profile of innovators and early adopters of an innovation (Rogers, 2003).

Within the demonstrability of results element of the adopter profile, adopters generally found technology much easier to use than non-adopters. Adopters also found it easier to communicate the benefits and consequences of utilizing a new innovation and were more likely to grasp the apparent benefits of utilizing the innovation. Adopters were also more confident in their ability to communicate the benefits of using a new technology to others. The adopter description of demonstrability would be an individual who is comfortable demonstrating and communicating the results and benefits of a technology to others. This individual would likely be in a position of leadership at work or in the community who is able to confidently demonstrate to their peers the benefits of using new innovations. Within the demonstrability construct, the study results indicated that the adopters classified were opinion leaders. The behavior exhibited by the respondents in this study met the criteria for opinion leaders by being more exposed to more forms of external communication and by being more open to the adoption of innovations. These findings support those of Rogers' (2003) work on opinion leadership and the classification of early adopters.

Visibility was the seventh dimension in which adopters were described. Under the measured visibility construct adopters were more likely to notice peers at work and home using new technologies. Adopters were also more likely to note the flexibility and

variability of new innovations within their environment. From the standpoint of visibility adopters can be described as individuals who are very observant in their perception of technology. These individuals will be able to note what innovations are being used and grasp quickly whether the innovation applies to any aspect of their life. The results of this study suggest that adopters in the sample are consistent with the classification of innovators and early adopters as implied by the ability of the classified adopters to understand and apply complex technical knowledge (Rogers, 2003).

The eighth and final construct under which adopters were described was trialability. Adopters can be characterized through trialability as individuals who have had a wide exposure to new technologies. These individuals find it easy to locate new innovations and have had ample opportunity and availability to test the innovations once found. The adopter also generally is more satisfied with the length of the trial period for new innovations than the non-adopter. This individual is one who can locate new technologies rapidly and efficiently. Once located the adopter is comfortable in their ability to test out the innovation to their satisfaction and is competent enough with new technologies to provide a fair assessment in a shorter period of time. The data supports the work of Rogers (2003) in the definition of early adopters by being capable of locating, learning, and applying new technologies.

Research Objective Two

The second objective of this research was to describe the innovation traits that facilitate technology and information dissemination in Brazil. To evaluate the innovation traits that enhance innovation adoption the perceptions of identified adopters

within each construct were used to indicate those innovation traits that were most conducive to the innovations' use.

The first component of innovation traits analyzed was that of voluntariness. The research indicated that innovations that an individual was expected to be able to use by their peers was influential in the adoption profile. Innovations that the individual voluntarily sought out also contributed to the adoption process. The innovation characteristics that facilitate adoption from the construct of voluntariness would thus be described as those innovations that are main stream within the community or workplace that is useful to the individual at the personal level. Innovations that are required at work would also aid in the adoption process if the assumption can be maintained that the employee has the necessary knowledge to use the innovation. The results of this study imply that the innovations adopted using the collective innovation decision process and utilized by opinion leaders within the community are more likely to experience higher rates of adoption. The relationship between an innovation's visibility and rate of adoption is positively related (Rogers, 2003).

The relative advantage component of innovation traits was characterized by the innovation being able to aid in the more rapid and easier completion of tasks. Innovations that provide higher quality work and a simpler lifestyle also enhanced the adoption process. The innovations that improved work quality and performance were preferred to the innovations that had a greater impact on the personal life. This finding indicates that the relative advantage type most valued by adopters in an innovation is the aspect of economic efficiency specifically as it relates to increased efficiencies of time or

energy (Koundouri et al., 2006). The higher the degree of relative advantage demonstrated a positive relationship with the rate of adoption (Rogers, 2003).

Within the construct of compatibility the innovation traits that enhanced adoption most significantly were those technologies that integrated well with work preferences and style. Complete compatibility with work and personal lifestyle was not as important to the identified adopters. This is interpreted to imply that innovations that improved the quality of life of the individual at work and at home were preferred to those that improved the quality of work. The findings of this research within the construct of compatibility support Rogers' (2003) finding that the compatibility of an innovation is measured within existing values, experiences, and needs and that higher degrees of compatibility within these areas has a positive relationship with the rate of adoption.

Image was the fourth construct against which the successful innovation profile was analyzed. Innovations that improved self-image and whose use raised the individuals' status within the community were the most indicated traits by adopters. The ability of the innovation to increase recognition of the individual was also important in facilitating adoption. A description of the image component of innovation traits that facilitate adoption would be a technology or innovation that the user can visibly be seen using and that has some degree of complexity that others in the community both recognize and admire. The results of the study indicate that high degree of social status conferred by the adoption of an innovation has a positive relationship with the adoption rate of that innovation (Young, 2009).

The fifth component of innovation adoption traits was that of ease of use. Clear and understandable interaction with the innovation as well as a simple and straightforward means of using the innovation were the components that were most valued by adopters. The ability of the innovation to be easily learned, manipulated, and used were also desirable components for enhancing the adoption process. Within the ease of use facet of adoption traits, the innovation should be simple, easy learn and use, and minimally complex in order to achieve the highest rate of adoption. Rogers (2003) proposed that the complexity of the innovation is inversely related to the rate of adoption for that innovation. The research supports Rogers' findings.

Result demonstrability was the sixth element to be evaluated. Readily apparent results, ease of communication, and simple to demonstrate to others were the innovation traits that were most desired by adopters within the construct. Innovations that meet these criteria would be those that are simple and straightforward. Extra complexity beyond the requirement for the innovations targeted use would be considered a negative factor impacting adoption by respondents. The data suggests that innovations that are easily communicated and demonstrated have a positive relationship with the rate of adoption and are consistent with Rogers' (2003) theory on observability.

The seventh component evaluated was visibility. Innovations that others commonly use have a strong impact on the adopter decision to adopt the innovation. Technologies that are used in the workplace and have multiple applications also contributed to innovation adoption. The successful innovation would be adopted at the

workplace or within the community as a labor saving device and which the adopter has some experience in using (Young, 2009).

Trialability was the last innovation adoption trait described by this study. Trialability revolves around the ability of the innovation to be discovered, located, and tested. Individual adopters who were able to discover the existence of an innovation and were then able to locate a model to test were more likely to adopt the innovation. This implies that efforts to promote a new innovation should begin at the information dissemination level so that adopters can be exposed to the technology (van der Gaast, et al., 2009). The innovation should then be made as readily available as possible with a sufficient trial period such that the probability of adoption is increased. Innovation theory surrounding trialability suggests that greater rates of trialability are positively related to adoption rates (Rogers, 2003) which is supported by the data of this study.

Research Objective Three

The third objective of this study was to describe agricultural innovation adoption processes in Brazil.

The study participants were classified into the five adopter categories proposed by Rogers (2003) based on the survey responses. Innovators accounted for .03% of the sample while twelve percent of the respondents were classified as Early Adopters. The Early Majority category was classified at 30.2% of the sample while the Late Majority and Laggards accounted for 40.4% and 5.1% respectively. Rogers (2003) described innovators as individuals who were venturesome, had control of significant financial resources, and were able to grasp and understand new and complex innovations.

Similarly, early adopters had a high social status among their peers and were considered to be opinion leaders. The data from this research indicated that the individuals classified as adopters met the criteria for either innovators or early adopters. This was reinforced by the adopters' cumulative percentage of the sample.

The adoption process was found to be facilitated by peer pressure. Increased peer pressure to use a new innovation contributed to the adopter becoming more receptive to adoption. Innovations that increased productivity and matched the individual's work output and style were also shown to increase the likelihood of adoption as were the perceptions of status and ease of manipulation. Difficulty in communicating or perceiving the benefits of using a new innovation were found to negatively impact the adoption process. The data from this study indicated that early adopters met the criteria as opinion leaders in the social system of Rio Grande do Sul, Brazil. The early adopters were shown to value social status and compatibility with needs in their innovation adoption decision. The data demonstrated that adopter categorization was consistent with the S-shaped adoption curve as proposed by Rogers (2003) and that the adoption process in Rio Grande do Sul, Brazil is comparable.

Research Objective Four

The fourth objective of this study was to identify the key elements and barriers of information transmission and adoption in Brazil.

Elements of information transmission that facilitated adoption were the perception of the innovation as a status symbol and the innovation's ability to increase productivity at work. The ability of an innovation to increase public image and to

improve the quality of life for the individual by reducing pressure both at work and at home were also found to enhance the adoption process (Huang, Shih, & Wu, 2011).

Barriers to transmission were identified as those innovations that focused only on improving the quality of the output at work. Innovations that were perceived as complicated or overly complex were found to negatively impact the adoption decision by participants and were thus identified as barriers to transmission. Respondents were more concerned with increasing personal utility and simplicity than with improving work output or quality. In keeping with Rogers' (2003) theory, the data suggested that in Rio Grande do Sul, Brazil, high levels of complexity and low compatibility of use had an inverse relationship to the decision of the individual to adopt an innovation.

Recommendations for Practitioners

New technologies and innovations are currently communicated by traditional methods. As innovations become more complex and technologically advanced, the conventional methods through which information is disseminated is not being changed to more improved communication and accessibility of information (Oliven & Rietz, 2004). If the traditional channels are not able to effectively communicate the specific components of an innovation to the consumer, then adoption rates will remain low. Change agents should target opinion leaders within the social system in order to facilitate the communication of the characteristics of an innovation and increase the rate of adoption (Rogers, 2003). Information exchange should be targeted to the individual specifically based on characteristics about the innovation itself and the characteristics of the intended target audience.

Within the context of price discovery technology as an innovation, complex innovations such as futures markets were shown to have a lower rate of participation from the sample. The data indicated that associated profit from price risk management would engage adopters in as much as it provided a relative advantage over the current market conditions and gave some economic incentive to the individual (Koundouri, et al., 2006). Practitioners should focus on minimizing the complexity of the system while clearly and concisely communicating the benefits to the innovators and opinion leaders within the system. Based on the results of this study, focusing on the workplace and communities is the most effective way to transmit information about a new innovation. Leaders in the workplace and communities must be made aware of the new innovations that can improve the lifestyle of the individual. The communication should be made in a clear and concise manner in order for the adoption process to be enhanced (Moriba et al., 2011). Once the leaders have chosen to test a new innovation, the innovation should be made readily available for them so they may evaluate the innovation for a reasonable trial period (Rogers, 2003). Vocational education or workplace adoption would be appropriate vehicles to accomplish the goal of increasing the rate of adoption among the population (Erbaugh et al., 2007).

New innovations should be aesthetically pleasing. Peer pressure and the status that ensues from using new technologies are important to improving the adoption rates of the early and late majority adopter categories. The results of this study suggest that practitioners' resources should be focused on ensuring that clear and user friendly technical support be allocated to all components of the target population in order to

minimize adopter perceptions of complexity about the innovation (Nin et. al, 2003). The innovation should not be work specific but varied in application and user friendly to the individual.

The research does not indicate that educational gaps exist between adopters and non-adopters in Rio Grande do Sul, Brazil. Adopters were demonstrated to have equivalent levels of education to non-adopters. Practitioners seeking to effect successful dissemination of an information or technology should focus on improving innovation communication and educating all of the intended audience in order to positively influence the acceptance of innovations (Baker et al., 2007).

Recommendations for Future Research

During the course of conducting this study, multiple questions arose relating to the dissemination of information in Brazil that rate additional investigation. Based on an extensive review of the literature, the amount of diffusion research conducted in identified developing countries is both narrow and limited in scope. Replication of this study is recommended for future research in order to validate the findings and increase the body of knowledge surrounding the innovation adoption characteristics of the population of Rio Grande do Sul, Brazil.

Throughout the adoption process the impact of opinion leadership was significant on the likelihood of an innovation's adoption. The results of this study indicated that higher social status conferred by the adoption of an innovation contributed to its adoption as well (Rogers, 2003). There is an implicit level of trust that non-adopters place in the opinion leaders and adopters as a result of the individual adoption decision.

The level of trust and the role that it plays in adoption process is difficult to measure explicitly. Further inquiry should be focused on determining how significant the trust variable factors into the adoption equation and also on ways that trust can be gained or enhanced by change agents.

Additional investigation into the innovation dissemination process should be conducted in other provinces of Brazil in order to compare the adopter demographics and innovation traits that facilitate adoption. This additional research would allow the researcher to contribute to the overall body of knowledge by being able to generalize the results to the country's population at the macro level (MacVaugh & Schiavone, 2010).

This research identified differences in age between adopters and non-adopters. Additional education has been shown to increase the acceptance of new technologies at all ages (Baker, Al-Gahtani, & Hubona, 2007). Future research should be focused on identifying the most effective channels through which to communicate new innovations to agriculturists.

The impacts of societal influences and social status were a common theme that emerged during the course of this study. The data indicated that the adoption process was enhanced when innovations were able to increase awareness in these components of the adoption cycle. Further investigation into the specific characteristics of opinion leaders and innovators should be conducted in order to better understand the social dynamics that contribute to the adoption process (Spielman, 2005).

The ability to quantify the adoption rate and innovation traits that enhance the adoption process is also of significant interest. Further inquiry should be directed using

longitudinal research or an experimental research design in order to specifically quantify the relationships between innovation characteristics, adopter characteristics, and the rate of adoption. A broader grasp of these relationships would aid in the understanding the elements that impact the adoption process and diffusion of technology (Roberts et al., 2016).

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APPENDIX A

SURVEY INSTRUMENT

Voluntariness

My peers expect me to use technology (internet, cell phone, email, etc...) to determine market price information.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
○	○	○	○	○

My use of technology to locate price information is voluntary (as opposed to being required by my job).

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
○	○	○	○	○

I am not required to use technology to locate information and prices as part of my job.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
○	○	○	○	○

Technology might be helpful in performing my job but is not required.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
○	○	○	○	○

Relative Advantage

Using technological innovations enables me to accomplish my tasks more quickly.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
○	○	○	○	○

Using technological innovations improves the quality of the work I do.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
○	○	○	○	○

Using technological innovations makes it easier to do my job.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
○	○	○	○	○

The disadvantages of using technology in my daily life outweighs the advantages.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
○	○	○	○	○

Overall, technology improves my job performance.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

O	O	O	O	O

Using technological innovations enhances my effectiveness at my job.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
O	O	O	O	O

Using technological innovations gives me greater control over my work.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
O	O	O	O	O

Using technological innovations increases my productivity.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
O	O	O	O	O

Compatibility

Using agricultural technology is compatible with all aspects of my work.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
O	O	O	O	O

Using agricultural technology is completely compatible with my current situation.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
O	O	O	O	O

I think that using agricultural technology fits well with the way I like to work.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
O	O	O	O	O

Using agricultural technology suits my work style.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
O	O	O	O	O

Image

Using agricultural technology improves my images within my community.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
O	O	O	O	O

Because of my use of agricultural technology, others in my community see me as a more valuable pe

Neither Agree nor

Strongly Disagree	Disagree	Disagree	Agree	Strongly Agree
☐	☐	☐	☐	☐

People in my community who use agricultural technology have more prestige than those who do not.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
○	○	○	○	○

Using agricultural technology is a status symbol in my community.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
○	○	○	○	○

Ease of Use

I believe that agricultural technology is cumbersome to use.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
○	○	○	○	○

It is easy for me to remember how to retrieve information using agricultural technology.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
○	○	○	○	○

Using agricultural technology to find price information requires a lot of mental effort.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
○	○	○	○	○

Using agricultural technology to locate price information is often frustrating.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
○	○	○	○	○

My interaction with agricultural technology is clear and understandable.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
○	○	○	○	○

I believe it is easy to get agricultural technology to do what I want it to do.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
○	○	○	○	○

Overall, using agricultural technology is easy for me.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree

○	○	○	○	○

Learning to use agricultural technology is easy for me.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
○	○	○	○	○

Result Demonstrability

I would have no difficulty telling others about the results of using agricultural technology to locate prices.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
○	○	○	○	○

I believe I could communicate to others the benefits of using agricultural technolgy.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
○	○	○	○	○

The results of using agricultural technology are apparent to me.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
○	○	○	○	○

I would have difficulty explaining why using agricultural technology may or may not be beneficial.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
○	○	○	○	○

Visibility

I have seen others use agricultural technology.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
○	○	○	○	○

In my community, one sees many applications of new agricultural technologies.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
○	○	○	○	○

I have seen agricultural technologies in use outside of my operation.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
○	○	○	○	○

Agricultural technologies are *not* very visible in my community.

Neither Agree nor

Strongly Disagree	Disagree	Disagree	Agree	Strongly Agree
O	O	O	O	O

It is easy for me to observe others using agricultural technologies in my community.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
O	O	O	O	O

Trialability

I have had a great deal of opportunity to try various applications of agricultural technologies.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
O	O	O	O	O

I know where I can go to satisfactorily try out new agricultural technologies.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
O	O	O	O	O

Agricultural technology was available for me to test run various applications.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
O	O	O	O	O

Before deciding whether to use agricultural technologies for finding price information, I was able to properly try them out.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
O	O	O	O	O

I was able to use agricultural technology on a trial basis long enough to see what it could do.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
O	O	O	O	O

Demographics

I am a:

O Male

O Female

I was born in the year:

My highest completed level of education was:

O I did not go to school

O Some College

- ○ Primary or Grade school
- ○ Secondary or High School
- ○ Undergraduate
- ○ Graduate, Professional, or Post-Graduate Degree

My occupation is:

- ○ Farming
- ○ Related Agricultural Industry
- ○ Marketer
- ○ Non-Agriculturally related industry
- ○ Other

IRB NUMBER: IRB2016-0063D
IRB APPROVAL DATE: 01/26/2017
IRB EXPIRATION DATE: 01/15/2018

APPENDIX B

INNOVATION DIFFUSION AMONG FARMERS IN DEVELOPING COUNTRIES

You are invited to join a research study to look at methods of determining market price in Brazil. Please take whatever time you need to discuss the study with your family and friends, or anyone else you wish to. The decision to join, or not to join, is up to you. In this research study, we are investigating how technology can improve your knowledge of timely market prices.

If you decide to participate you will be asked to complete a short survey. We think this will take you 20 minutes. The survey will consist of several questions about how you get price information, and the ways that you receive pricing information.

You can stop participating at any time. If you stop you will not lose any benefits.

It is reasonable to expect that you will be able to access timely price information from participating in this research. However, we can't guarantee that you will personally experience benefits from participating in this study. Others may benefit in the future from the information we find in this study.

We will not collect any identifiable information from you and will take steps to keep any information about you confidential, and to protect it from unauthorized disclosure, tampering, or damage. Only the researchers will have access to your records during this process and all electronic data will be maintained on encrypted computers.

Participation in this study is voluntary. You have the right not to participate at all or to leave the study at any time. Deciding not to participate or choosing to leave the study will not result in any penalty or loss of benefits to which you are entitled.

Information about you will be kept confidential to the extent permitted or required by law. People who have access to your information include the Principal Investigator and research study personnel. Representatives of regulatory agencies such as the Office of Human Research Protections (OHRP) and entities such as the Texas A&M University Human Subjects Protection Program may access your records to make sure the study is being run correctly and that information is collected properly. Please call Thomas Wynn at +01 (979) 575-0095 or email t_wynn46@tamu.edu if you have questions about the study, any problems, unexpected physical or psychological discomforts, any injuries, or think that something unusual or unexpected is happening. Additional contact related to this research may also be directed to Dr. Robert Strong at +01 (979) 845-1139 or email r-strong@tamu.edu. For questions about your rights as a research participant; or if you have questions, complaints, or concerns about the research, you may contact the Texas A&M University Human Subjects Protection Program at +01 (979) 458-4067, toll-free at +01 (855) 795-8636, or email at irb@tamu.edu.

Consent of Subject (or Legally Authorized Representative)

Signature of Subject or Representative Date

_____

IRB NUMBER: IRB2016-0063D
IRB APPROVAL DATE: 02/22/2016
IRB EXPIRATION DATE: 02/15/2017

APPENDIX C

IRB APPROVAL

DIVISION OF RESEARCH

TEXAS A&M UNIVERSITY

Submission Approval DATE: January 26, 2017

MEMORANDUM

TO: Robert Strong Jr, PhD
ALRSRCH - Agrilife Research - Ag Leadership, Education & Communication

FROM: Dr. David Martin
Chair, TAMU IRB

SUBJECT: Approval for Submission Response for IRB Continuing Review Form REF: 049002

Study Number: IRB2016-0063D
Minimal Risk Expedited 7

Title: Innovation Diffusion Among Farmers in Developing Countries

Initial Application Approval Date: 02/22/2016

Continuing Review Due: 12/15/2017

Expiration Date: 01/15/2018

Documents Reviewed and Approved: Only IRB-stamped approved versions of study materials (e.g., consent forms, recruitment materials, and questionnaires) can be distributed to human participants. Please log into iRIS to download the stamped, approved version of all study materials. If you are unable to locate the stamped version in iRIS, please contact the iRIS Support Team at 979.845.4969 or the IRB liaison assigned to your area.

Submission Components			
Study Document			
Title	Version Number	Version Date	Outcome
Phone Script (English)	Version 2.1	02/04/2016	Approved
Phone Script (Portuguese)	Version 2.1	02/04/2016	Approved
Email Solicitation (English)	Version 2.1	02/04/2016	Approved
Email Solicitation (Portuguese)	Version 2.2	02/04/2016	Approved
160127 Survey	Version 1.1	01/27/2016	Approved
150803 Survey	Version 1.1	01/27/2016	Approved

750 Agronomy Road, Suite 2701
1186 TAMU
College Station, TX 77843-1186
Tel. 979.458.1467 Fax. 979.862.3176
http://rcb.tamu.edu

Questions TRANSLATED Portuguese			
Study Consent Form			
Title	Version Number	Version Date	Outcome
Informed Consent	Version 2.1	02/17/2016	Approved

Document of Consent: Waiver approved under 45 CFR 46.117 (c) 1 or 2/ 21 CFR 56.109 (c)1

Comments:

- This IRB study application has been reviewed and approved by the IRB. Research may begin on the approval date stated above.
- Research is to be conducted according to the study application approved by the IRB prior to implementation.
- Any future correspondence should include the IRB study number and the study title.

Investigators assume the following responsibilities:

1. **Continuing Review:** The study must be renewed by the expiration date in order to continue with the research. A Continuing Review application along with required documents must be submitted by the continuing review deadline. Failure to do so may result in processing delays, study expiration, and/or loss of funding.
2. **Completion Report:** Upon completion of the research study (including data collection and analysis), a Completion Report must be submitted to the IRB.
3. **Unanticipated Problems and Adverse Events:** Unanticipated problems and adverse events must be reported to the IRB immediately.
4. **Reports of Potential Non-compliance:** Potential non-compliance, including deviations from protocol and violations, must be reported to the IRB office immediately.
5. **Amendments:** Changes to the protocol and/or study documents must be requested by submitting an Amendment to the IRB for review. The Amendment must be approved by the IRB before being implemented.
6. **Consent Forms:** When using a consent form or information sheet, the IRB stamped approved version must be used. Please log into iRIS to download the stamped approved version of the consenting instruments. If you are unable to locate the stamped version in iRIS, please contact the iRIS Support Team at 979.845.4969 or the IRB liaison assigned to your area. Human participants are to receive a copy of the consent document, if appropriate.
7. **Post Approval Monitoring:** Expedited and full board studies may be subject to post approval monitoring. During the life of the study, please review and document study progress using the PI self-assessment found on the RCB website as a method of preparation for the potential review. Investigators are responsible for maintaining complete and accurate study records and making them available for post approval monitoring. Investigators are encouraged to request a pre-initiation site visit with the Post Approval Monitor. These visits are designed to help ensure that all necessary documents are approved and in order prior to initiating the study and to help investigators maintain compliance.
8. **Recruitment**: All approved recruitment materials will be stamped electronically by the HRPP staff and available for download from iRIS. These IRB-stamped approved documents from iRIS must be used for recruitment. For materials that are distributed to potential participants electronically and for which you can only feasibly use the approved text rather than the stamped document, the study's IRB Study Number, approval date, and expiration dates must be included in the following format: TAMU IRB#20XX-XXXX Approved: XX/XX/XXXX Expiration Date: XX/XX/XXXX.
9. **FERPA and PPRA:** Investigators conducting research with students must have appropriate approvals from the FERPA administrator at the institution where the research will be conducted in accordance with

the Family Education Rights and Privacy Act (FERPA). The Protection of Pupil Rights Amendment (PPRA) protects the rights of parents in students ensuring that written parental consent is required for participation in surveys, analysis, or evaluation that ask questions falling into categories of protected information.

10. **Food:** Any use of food in the conduct of human research must follow Texas A&M University Standard Administrative Procedure 24.01.01.M4.02.
11. **Payments:** Any use of payments to human research participants must follow Texas A&M University Standard Administrative Procedure 21.01.99.M0.03.
12. **Records Retention**: Federal Regulations require records be retained for at least 3 years. Records of a study that collects protected health information are required to be retained for at least 6 years. Some sponsors require extended records retention. Texas A&M University rule 15.99.03.M1.03 Responsible Stewardship of Research Data requires that research records be retained on Texas A&M property.

This electronic document provides notification of the review results by the Institutional Review Board.